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EDITORIAL

As the *British Journal of Anaesthesia* is entering upon its second quarter of a century in spite of wars, rumours of wars, and many vicissitudes, the Board of Management and Publishers have decided to embark on bi-monthly publication instead of quarterly.

We are further marking entry into the new era by a striking change of format. Lest those who have learnt to distrust appearance should suppose that the talents of the Board of Management have expended themselves on the cover to the detriment of the contents, may we remind you of Coventry Patmore's:

> " Beauty deceives," Oh shaft well shot
> To hit the mark's true opposite.
> That ugly good is scorned proves not
> That beauty deceives, but lack of it,

so that you may turn from the contemplation of the cover refreshed and invigorated, to study the contents.

Perhaps one effect of six issues annually will be to attract those authors who, anxious to be the first in the field with some startling discovery, tend to send their writings to the non-specialist medical press. It is disheartening to be compelled to delay the publication of researches often eighteen months to two years after the work has been completed.

In this issue a new feature, and one which we trust will grow in importance with the passage of the years, is the Educational Supplement. The purpose of this will be to provide information regarding the educational activities in the specialty of anaesthesia and to publish articles of general interest to the trainee. We must feel sympathy for the present-day aspirant to consultant status. Having survived the hectic days of an overcrowded medical curriculum, he must face with equanimity a further seven years hard grind. If he hopes to succeed in his specialist examinations in anaesthesia, he must keep in constant touch with the ever expanding literature, not only of his own specialty, but of practically every branch of medicine, of surgery, and of all the basic sciences. We hope that the features of the Educational Supplement will assist him in this really formidable task. Maybe too, those responsible for teaching both postgraduates and undergraduates will find here encouragement, a source of information and a forum of opinion.

THE Ministry of Health has recently circularized the medical profession regarding economy in prescribing. This circular was mainly concerned with the substitution of national formulae for proprietary drugs. Maybe it is not apparent

at once to anaesthetists how they can help in this campaign, yet they can hardly be unaware of the ever increasing cost of the materials in the service they render. Whereas an "old fashioned" anaesthetic would be covered by the cost of, at the most, a few ounces of ether (pennies) and a minute sum for premedicant drugs, a little arithmetic will show that an anaesthetic of the modern cocktail variety will entail the expenditure of several shillings. In one small region the expenditure on anaesthetic gases for 1950/51 was £15,745, in 1951/52 £17,666, and in 1952/53 £20,654. The basic cost of the gases themselves has not changed appreciably; there is no reason to suspect that the number of operations has risen in this period, nor, it appears, has there been any great increase in beds. Possibly most of this increase can be accounted for by a tendency in recent years to use increased flow rates and it is therefore justifiable, for whatever economy is effected it must not be at the expense of the patient's well-being.

Nevertheless, it does seem to us that there are ways in which anaesthetists can help appreciably and with only a little care. In one particular, for example the method of usage of thiopentone, economies could be effected simply. It has appeared that too often the large 5 g. containers are used and half their contents wasted at the end of the list. A further interesting point is that at hospital rates, to buy 25 g. of thiopentone in 0.5 g. ampoules costs 58*s*. 6*d*.; in 1 g. ampoules the same quantity costs 44*s*. 0*d*. It therefore seems uneconomical to use 0.5 g. ampoules when a list of operations is in progress. Further, too often anaesthetists are apt to draw up into the syringe more thiopentone than they are likely to require for the particular case. During the injection the solution becomes contaminated with the patient's blood and therefore the residue, at the end of the case, has to be discarded. A simple economy of drawing up only 10 ml. or, at the most, 15 ml. for each case, and leaving the remainder in the ampoule would make, in the course of a year, an appreciable economy. Still more economy would be effected if more three-way taps were employed during lists, so that the syringes themselves do not become contaminated and can be used from case to case without loss of their residual contents.

We do not consider it inappropriate to appeal to all anaesthetists to use every means under their control to effect economy, and so enable the Ministry to employ the financial resources of the National Health Service to the best effect.

THE *British Journal of Anaesthesia* wishes to offer its congratulations to the Association of Operating Theatre Technicians, who have now been recognized by the Board of Registration of Medical Auxiliaries. This should be a considerable step in the improvement of the status, conditions of work and supply of these important assistants.

Brit. J. Anaesth. (1954), **26**, 3.

PRESSURE-FLOWRATE CHARACTERISTICS OF EXPIRATORY VALVES

With some suggested criteria for an Ideal Valve

BY

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INTRODUCTION

THE expiratory valve in a continuous flow anaesthetic system, although small in size, plays an important part in determining the nature and extent of certain physiological upsets which sometimes accompany inhalation therapy. Too little attention has in the past been directed towards this important component of the anaesthetic outfit. For at least the last 15 years the design of the expiratory valve, in Britain at any rate, has remained unaltered. Anaesthetists nevertheless accept the valves at present offered to them as being not unsatisfactory.

The "setting" of the valve determines the mean pressure in the anaesthetic system and in the patient's respiratory tract. This in turn determines the effort required of the patient to expire through the valve, and also, indirectly, the size of his physiological dead space. The latter is so because, as the mean pressure in the respiratory tract is raised, the functional residual air, and hence the dead space, becomes increased (Mushin and Rendell-Baker, 1953). In addition to these considerations, as is shown later, the opening pressure of the expiratory valve must have some relation to the collapsing pressure of the reservoir bag. The former should be slightly greater than the latter, or the bag will not act as a reservoir.

The following investigations into the behaviour and characteristics of certain expiratory valves were undertaken to determine not only the characteristics of available valves, but also in what way they fall short of those theoretically desirable in an "ideal" valve. Two experimental investigations of valve characteristics have been published within recent years (Comroe and Kraffert, 1950; Cara, 1953). The former deals with valves of types not readily available in this country, while the latter is concerned with unidirectional valves found in absorption circuits.

TYPES OF VALVES INVESTIGATED

Of the various valves available, the following were selected as being well known and either in common use or suitable for use in anaesthetic apparatus.

(1) *The Heidbrink Type Valve* (fig. 1).

This consists of a spring-loaded disc bearing on a seating. The centre of the disc carries a pin running in a guide. The compression of the spring can be adjusted by rotating the knurled thumb screw control. By this means the pressure drop

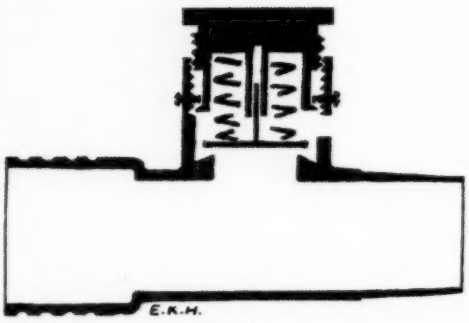

FIG. 1
Section of Heidbrink type valve.

across the valve for any particular flow is gradually increased until, when the control is screwed down sufficiently, the disc is clamped on its seating so that it cannot be opened. The valve is then said to be completely closed. This valve with its provision for adjustment of the spring loading of the disc, is almost universal in British anaesthetic apparatus.

(2) *The E.S.O. Valve* (fig. 2).

This valve was designed for the E.S.O. Chloroform Inhaler invented by the Department of Anaesthetics at Oxford, during the last war, for use by parachute troops. The valve differs from the Heidbrink pattern in that the compression of the spring cannot be adjusted. Complete closure of the valve is effected by rotating the head of the valve; the effect of this is to close off the holes through which the expired gases reach the outer air. The valve, therefore, has only two settings—"open" and completely closed. In both settings, of course, the spring bears with the same small force on the disc.

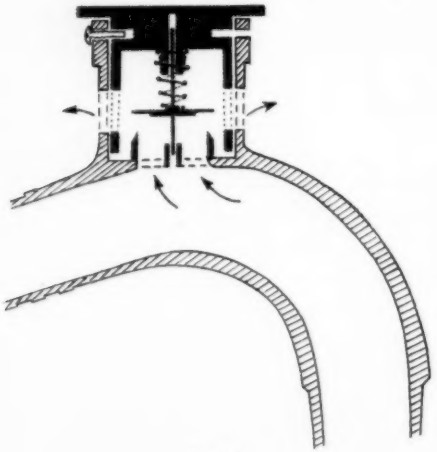

FIG. 2
Section of E.S.O. valve.

(3) *The Moulded Rubber Valve* (fig. 3).

This valve is commonly fitted to breathing apparatus in the physiological laboratory and to some forms of apparatus for measurement of Basal Metabolic Rate. A rubber moulding allows the passage of gases in one direction, but not in the other.

EXPERIMENTAL ARRANGEMENT

The experimental arrangement is illustrated in figure 4. A Heidbrink valve is shown in what will be termed the "upright" position—that is with the valve head above the main body of the valve. The term "inverted" position will be used to denote that the head is below the body of the valve. Oxygen was used in all the experiments, as it and a suitable rotameter were readily available. The position in the circuit at which the water manometer was inserted seemed to be the least objectionable for determining the pressure* "inside" the valve.

In the case of the moulded rubber valve the circuit was modified to that shown in figure 5.

The manometer readings with the valve

* Here the term pressure is used to denote excess of pressure above atmospheric.

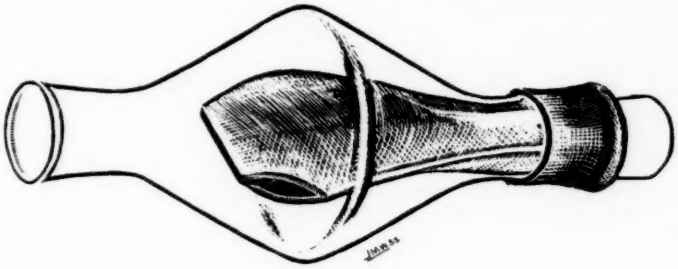

FIG. 3
The moulded rubber valve.

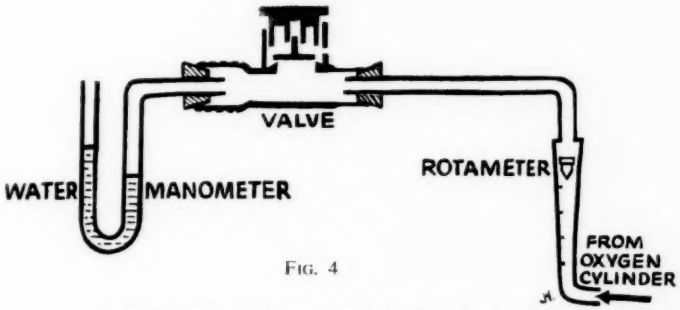

FIG. 4
Experimental arrangement with Heidbrink type valve.

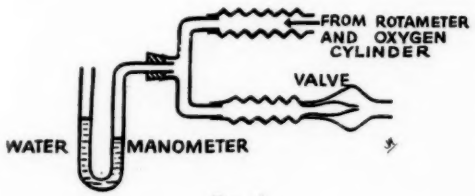

FIG. 5
Modified arrangement used with moulded rubber valve.

connected could be taken as a reliable measure of the pressure inside the valve, because, when the valve was removed, the manometer showed zero pressure for all flowrates up to 35 litres per minute.

EXPERIMENTAL PROCEDURE

To determine the "opening pressure" of the valve (indicated on the graphs as the pressure for zero flow through the valve) the needle valve on the oxygen cylinder was slowly opened so that a positive pressure developed inside the system until the disc just lifted. This was indicated by a sudden small drop in pressure due to the escape of a small volume of gas through the valve. The disc then dropped back on to its seating until the pressure inside once again built up to the opening pressure. The reading of the manometer immediately before the sudden small drop in pressure was taken as the opening pressure.

The flow was then increased, in steps of 5 litres per minute, up to 35 litres per minute and then decreased in similar steps. The reading of the water manometer was taken at each step. This cycle

of operations was performed at least three times for each test of each valve, and five times on those which showed large variations from one cycle to another. The points plotted in the graphs are mean values derived from these cycles.

RELATION BETWEEN PRESSURE INSIDE THE VALVE AND FLOWRATE THROUGH THE VALVE

This is very variable both for different settings of any one valve (fig. 7) and between one valve and another (fig. 6). In both figures the measurements are for valves in the upright position.

The characteristics (fig. 6) of the E.S.O. and moulded rubber (R) valves, follow smooth curves which show a gradual increase in the rate of rise of pressure with flowrate, as the higher flowrates are approached. Although the characteristics of the valves of the Heidbrink pattern (H1 to H6) are much less smooth, this may be due to frictional effects distorting the curve.

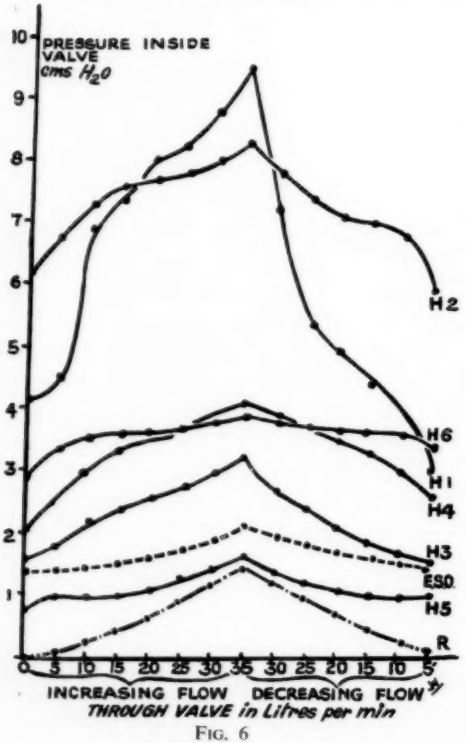

FIG. 6

Comparison of pressure-flowrate characteristics of various valves.

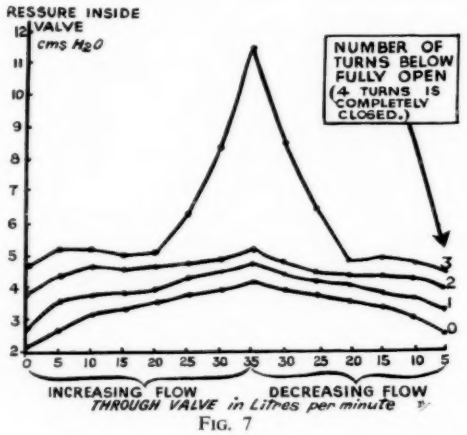
RESSURE INSIDE VALVE cms H_2O
NUMBER OF TURNS BELOW FULLY OPEN (4 TURNS IS COMPLETELY CLOSED.)
INCREASING FLOW
DECREASING FLOW
THROUGH VALVE in Litres per minute

FIG. 7

Comparison of pressure-flowrate characteristics for various settings of one Heidbrink type valve.

In general there is an increase of pressure with increase of flowrate. The rate of increase of pressure, however, usually falls off somewhat for medium flowrates and often increases again as the maximum flowrate used (35 litres per minute) is approached. This is particularly marked when the valve is almost completely closed (fig. 7).

In some of the valves, the pressure for a given flowrate was higher as the flowrate was being increased than when it was being decreased. This is attributed to sticking of the valve due to friction, either between the pin and its guide or between

the spring and the walls of the valve head. It is particularly marked in valve H1.

While it is probably difficult to reduce by much the friction between the pin and its guide, it would require but slight modification of design to eliminate it between the spring and the walls of the valve head—either by using a smaller diameter spring or by winding the spring on a conical former. Both these modifications have been used in the E.S.O. valve.

RESULTS

Comparison of Different Valves.

Six valves of the Heidbrink pattern (H1 to H6) were tested. H4 was new and unused, while the remainder were in normal use in operating theatres. The E.S.O. valve and the moulded rubber valve had been used for some time.

The graphs in figure 6 show the wide variations encountered in pressure in the different valves for various flowrates. Nearly all the Heidbrink valves operate at comparatively high pressures. In the one exception (H5), in which the pressures were very low, the spring was found to be unduly shortened so that movement of the disc did not begin to compress the spring until a moderate flowrate had been attained. Consequently the valve leaked when in the inverted position.

Thus it is apparent that the moulded rubber valve operates at the lowest pressures. The E.S.O. valve operates at slightly higher pressures, but still lower than any of those of the Heidbrink pattern which were working properly.

Effect of Various Settings of the Valve.

Figure 7 demonstrates that in the case of H4, when the valve is closed by up to 2 of the possible 4 turns of the knurled screw, the increase in pressure is quite small for flowrates up to 35 litres per minute. On closing the valve by more than 2 turns the rate of rise in pressure with flowrate becomes very steep at the higher flowrates. This is attributed to the valve disc reaching the limit of its travel for some particular flowrate so that greater flows have to be forced through an orifice of constant size.

Effect of Orientation of the Whole Valve.

This was examined for two of the Heidbrink valves (H2 and H4) and the E.S.O. valve. It was found that inverting the valves from the upright position decreased the pressure at all measured flowrates by about 0.8 cm. of water for H2, 1.3 for H4 and 0.3 for the E.S.O. As a check on these observations, the expected decrease in pressure for H2 was estimated from measurement of the weight and surface area of the valve disc and found to be in close agreement with the measured value for that valve.

Effect of Moisture on the Valve.

For this test the oxygen was bubbled through a bottle of warm water interposed between the rotameter and the valve, so that the gas passing through the valve was saturated with water vapour and contained some small water droplets. This mixture was passed through the valve at 15 litres per minute for five minutes before taking any observations, and was used consistently during the test.

For valve H4 the effect of moisture was to increase the opening pressure by 0.7 cm. of water and the pressure at a flowrate of five litres per minute by 0.3 cm. of

water. At higher flows, however, the effect was negligible.

In the moulded rubber valve the effect on the opening pressure and on the pressure for flows above 25 litres per minute was negligible, while for intermediate flows the pressure was increased by between 0.1 and 0.2 cm. of water.

Effect of Ether Vapour on the Moulded Rubber Valve.

For this test the oxygen was passed through an Oxford vaporizer, interposed between the rotameter and the valve. The vaporizer was set to deliver maximum ether concentration (normally 25 per cent). The exact concentration would, of course, vary with the oxygen flowrate, but it seems reasonable to assume that clinically speaking it could always be regarded as "high". The mixture was passed through the valve at 15 litres per minute for five minutes before taking any observations and was used consistently during the test.

The effect of the mixture on the pressure-flowrate characteristic was negligible.

Variation of Characteristics with Time.

Although this phenomenon was not deliberately investigated, some relevant data were obtained incidentally. The "dry" characteristic for H4 in the upright position was checked immediately before examining the effect on it of moisture, and it was found that pressure for all flows had increased by about 0.5 cm. of water on the average. The dry characteristic of the moulded rubber valve was checked immediately before examining the effect of ether vapour, and it was found that the pressures at all flows were about 25 per cent below those measured immediately before examining the effect of moisture. Subsequently after this valve had been lying on the bench for some weeks, it was found to be permanently slightly open.

The moulded rubber valve is not further considered because of its tendency to leak and because of its undesirably small opening pressure (q.v.).

THEORETICAL CONSIDERATIONS IN THE DESIGN OF AN IDEAL VALVE

In considering the desirable features which an ideal expiratory valve should have, we could not help coming to the conclusion that the ability to adjust the compression of the spring was unnecessary, except in certain remote and special requirements. It seems to us that the present Heidbrink valve, in which the spring can be compressed to a variable amount, is a carry-over from the days not so long distant when the setting of the valve was believed to be the main method of controlling the extent of rebreathing. Both theoretical and practical considerations have shown this to be false; the extent of rebreathing is more dependent on such facts as the relation between the minute volume respiration of the patient and the flow of fresh gases into the anaesthetic system (Macintosh and Mushin, 1947; Molyneux and Pask, 1951). Since the effect of increasing the compression of the spring is to raise the mean pressure in the respiratory tract, such a practice might be advocated for two purposes. Firstly, to increase the solution in the blood of the gases inhaled, an effect which is probably so small in extent that its value from a practical standpoint can be

ignored (Macintosh and Mushin, 1947). Secondly, to keep the lungs inflated during open chest operations and while the patient is breathing spontaneously. This method, involving "positive pressure breathing", has been very largely given up, its place being taken by a combination of induced apnoea and controlled respiration. In the theoretical consideration of the ideal valve, therefore, we discuss one in which the spring compression cannot be adjusted, and in which complete closure is effected by some other means, such as that in the E.S.O. valve.

In the case of a helical spring the formula

$$F = kx/l \quad . \quad . \quad . \quad (1)$$

expresses to a first approximation the relation between

F, the force exerted by the spring,
l, its unloaded length,
x, its compression (the distance the spring is compressed from its unloaded length), and
k, a constant involving the elastic modulus.

Let F_0 be the force and x_0 the compression when the disc is resting on its seating.

Then $F_0 = kx_0/l \quad . \quad . \quad (2)$

F_0 will be determined by the requirement that it be slightly greater than the weight of the disc, so that the valve will not leak when in the inverted position. Clearly, therefore, the weight of the disc must be small in order that F_0 and the opening pressure in the upright position may also be small.

The second criterion is that the pressure should increase very little as the flow increases. This means that the valve must open wide for a small increase in pressure, that is, x must increase rapidly for a slow increase in F. Expressing this mathematically dF/dx must be small.

Differentiating (1) we have

$$dF/dx = k/l$$

Therefore k/l must be small.

Further the length of the spring when in position with the disc on its seating is given by $l - x_0$. This must be not less than (and ideally equal to) c, the length of the spring when fully compressed, plus t, the required traverse of the disc,
that is

$$l - x_0 = t + c$$

Substituting for x_0 in (2) we have

$$F_0 = k\frac{l-(t+c)}{l}$$

$$= k\left(1 - \frac{t+c}{l}\right)$$

Thus, in order to make k/l small while keeping F_0 constant (at its optimum value)

either (1) k must be made small and l must be made large.
or (2) $t+c$ must be made large and l must be increased in proportion.
or (3) both.

That is to say that in order to construct a valve which will open a given amount for a minimum pressure (or open a maximum amount for a given pressure) either the spring must be very light and very long when freed from the valve, or the head of the valve must be made long and the length of the spring, when freed from the valve, increased in proportion, or both. Then, in any of these cases, the required traverse of the disc produces little increase in the force exerted on it by the spring.

Clearly it is not desirable to increase the length of the head of the valve appreciably, so that most of the improvement must be brought about by means of the first alternative.

There is a limit to the desirable smallness of the opening pressure, since this must be greater than the pressure required to fill the reservoir bag sufficiently. Experiments by one of us (Mapleson, 1953) have shown that in the case of a " one gallon " bag an expiratory valve opening pressure of not less than say 0.5 cm. water is required in order that a sufficient quantity of gas shall collect in the reservoir bag for the patient to draw the required tidal volume.

CONCLUSIONS

The characteristics of an " ideal " valve would be such that, when in the inverted position, it would open at a pressure of 0.5 to 1.0 cm. water, this requirement being determined by the characteristic of the bag. In addition, a physiological requirement is that this pressure should be exceeded as little as possible in the upright position and for flows up to say 30 or 40 litres per minute.

Theoretical considerations show that these requirements would be met by certain modifications of the spring and dimensions of the valve and by reducing the weight of the valve disc. Clinical practice suggests that adjustment of the compression of the spring is an unnecessary facility.

ACKNOWLEDGMENTS

Our thanks are due to Miss June Williams for figures 3 to 7, to Mr. E. K. Hillard for figure 1 and for assistance in the laboratory, and to Professor R. R. Macintosh and Dr. H. G. Epstein of Oxford for figure 2 and for the loan of the E.S.O. valve.

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VOLUME-PRESSURE CHARACTERISTIC OF THE "ONE GALLON" RESERVOIR BAG

BY

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IN the course of an investigation of expiratory valves in anaesthetic apparatus (Mushin and Mapleson, 1953), it was remarked that physiological considerations make it desirable for the valve to open and pass large flows for a small pressure drop. At the same time it was pointed out that in the usual semi-closed system, if this pressure drop was too small, the reservoir bag would not fill sufficiently for the patient to be able to draw the required tidal volume.

It was therefore thought of interest to determine the volume-pressure characteristic of reservoir bags. This was done with the apparatus shown in figure 1.

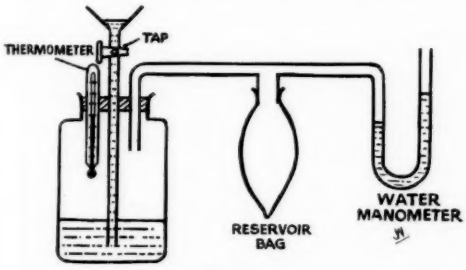

FIG. 1

Apparatus for determining volume-pressure characteristic of reservoir bag.

The apparatus was connected as shown and made air tight. By syphoning off water, the bag was completely emptied of air, this point being indicated by the manometer just beginning to show a negative pressure. Measured quantities of water were then poured into the funnel and admitted to the system by opening the tap. The pressure and temperature were noted after each addition. When a pressure of about 20 cm. of water had been attained, the process was reversed by syphoning off measured quantities of water. The point at which the bag was again just empty was determined. It was found that the loss of air through leakage in the course of a cycle of operations never exceeded 20 ml. or less than 1 per cent of the maximum volume passed into the bag. The temperature was maintained constant to within 1°C by judicious adjustment of electric fires, doors and windows in the room.

From a practical point of view it is not so much the volume of the bag which is of interest, but the volume which its contents would occupy when expanded to atmospheric pressure without change of temperature. This, the value used in the graph of figure 2, could be determined with sufficient accuracy by correcting for pressure, but without correcting for temperature or water vapour content variations.

One cycle of operation was performed on each of three bags. Bags 1 and 2 were

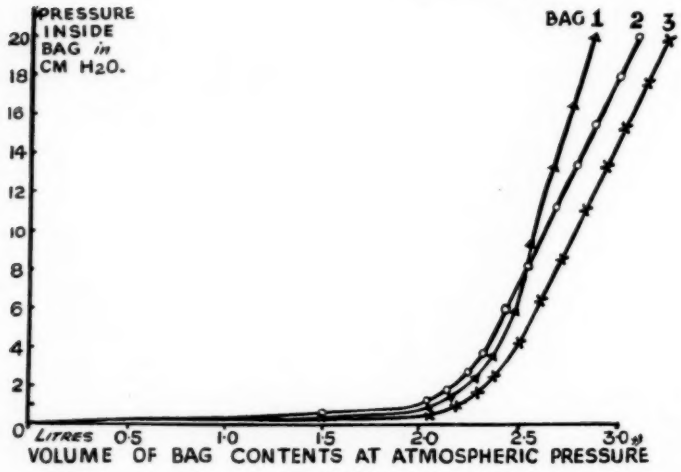

FIG. 2

Volume-pressure characteristics of three "one gallon" reservoir bags.

new and unused; bag 3 had been in use in theatre for some time. The results are shown in figure 2, where the pressures plotted are the means of the values for increasing and decreasing volumes. It is apparent that for volumes up to about 2 litres, where the bag appeared to be just taut, the pressure remains quite low (less than 1 cm. of water). Beyond this volume the pressure increases very rapidly, attaining a value of 20 cm. of water for a volume of between 2.9 and 3.2 litres depending on the particular bag used.

Two conclusions may be drawn from these graphs. Firstly, the so-called "one gallon" bag shows a sharp pressure rise when its contents exceed 2 litres (about half a gallon). Secondly, any expiratory valve which opens at a pressure of less than 1 cm., or at any rate 0.5 cm. of water may prevent adequate filling of the reservoir bag, so that it does not contain sufficient gas to supply the tidal volume of the patient.

ACKNOWLEDGMENTS

The author's thanks are due to Dr. William W. Mushin for encouragement in the research, to Miss June Williams for the figures, and to Mr. E. K. Hillard for assistance in the laboratory.

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Brit. J. Anaesth. (1954), **26**, 13.

A CLINICAL TRIAL OF LAUDOLISSIN AS A RELAXANT IN 524 CASES

BY

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THE search for synthetic muscle relaxants led Collier and Macauley (1952) to investigate the properties of Laudolissin, a drug previously synthesized by Taylor and Collier (1951). Its safety having been established, Bodman (1952 a) evaluated its curarizing abilities in conscious volunteers, and with Morton and Wylie (Bodman, Morton and Wylie, 1952) carried out the first clinical trials.

Its use in combination with other relaxants has been described (Bodman, 1952 b; Binning, 1953). The purpose of this paper is to evaluate the possibility of using Laudolissin as a substitute for d-tubocurarine chloride.

TABLE I
Nature of operations during which Laudolissin was used as relaxant

Nature of operation	No. of cases
Abdominal	434
Thoraco-abdominal	24
Thoracic	66
Total	524
Abdominal operations	
Oesophagus and stomach	145
Genito-urinary	48
Herniae	46
Gynaecological	45
Gall bladder and bile ducts	41
Colon and rectum	37
Sympathectomy	27
Appendicectomy	17
Laparotomy	13
Liver and spleen	10
For acute intestinal obstruction	5
Total	434

MATERIAL

During this trial Laudolissin was used by the authors, or under their supervision, in 524 cases (table I), in all of which d-tubocurarine chloride alone would normally have been employed. All administrations were to adults, the ages ranging from 18–80 years. The operations performed lasted, on the average, just under two hours, the operating times being shown in figure 1.

Anaesthetic Techniques. These did not vary from those normally employed. They are based on the principle that each drug should be administered for a specific purpose—thiopentone for narcosis, nitrous oxide and/or pethidine for analgesia, and relaxants for the production of good operating conditions (Gray and Rees, 1952). Details of the anaesthetics employed are given in table II. The patients' respiration was manually controlled in all instances where the chest was opened, and controlled or aided in the remainder.

Anaesthetists. In 40 per cent of cases the anaesthetists responsible for the administrations were of consultant status, in half of them they were of the senior registrar grade, while in the remainder they were registrars or senior house officers.

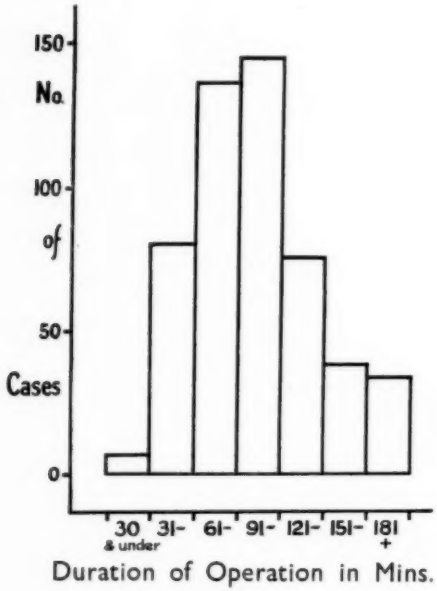

FIG. 1
Histogram showing duration of operation in the cases who received Laudolissin as a muscle relaxant.

TABLE II
Details of combinations of anaesthetic agents and relaxants used in this series

A—Anaesthetic combinations, irrespective of relaxant used

Anaesthetic	No. of cases
Thiopentone-nitrous oxide-oxygen ...	227
Thiopentone-nitrous oxide-oxygen-pethidine	182
Thialbarbitone-nitrous oxide-oxygen ...	18
Thiopentone-nitrous oxide-oxygen-methorphinan	19
Thiopentone-nitrous oxide-oxygen-ether	34
Thiopentone-nitrous oxide-oxygen-pethidine and ether	26
Thiopentone-cyclopropane and oxygen	18

B—Details of relaxants used

Relaxant		No. of cases
Laudolissin as sole relaxant		483
Laudolissin with other relaxants:		
(i) with gallamine triethiodide during operation	13	
(ii) with suxamethonium at beginning	4	
(iii) mixed with d-tubocurarine chloride (equal parts by volume)	24	
		41

OBSERVATIONS

Physical Properties. Precipitation of Laudolissin occurred when mixed with thiopentone or pethidine in 1–5 per cent solutions, and with gallamine triethiodide and atropine in all dilutions. There was no venous thrombosis or other evidence of irritant properties following administration of the drug.

Onset and duration of paralysis. An evaluation of the time of onset of paralysis and duration of action of Laudolissin can be made from (*a*) the conditions available for endotracheal intubation, and (*b*) from the onset and duration of apnoea and muscular relaxation.

(*a*) *Intubating conditions.* One of the earliest impressions was that endotracheal intubation was not as easy using Laudolissin as when d-tubocurarine chloride was employed. Observations were made, therefore, on the ease of intubation in 441 cases correlating this with the time after the injection of Laudolissin (table III).

TABLE III
Relationship of ease of intubation to time after injection of Laudolissin in 441 cases. Figures shown are actual number of cases in each group

Time after injection in minutes	Total No. of cases	Ease of intubation		
		Easy	Moderately easy	Difficult
1	151	58	53	40
2	130	63	48	19
3	93	74	13	6
4+	67	52	10	5

The division of cases into "easy", "moderately easy" and "difficult" was based on the impressions of the anaesthetist, and this table only includes cases intubated personally by the authors. Since a test dose of 10 mg. of Laudolissin was used in practically every case, it must be pointed out that the times are recorded

from administration of the main dose of the drug. On expressing these findings as a percentage (fig. 2) it may be seen that optimum conditions for intubation were not provided until 3 mins. after the injection of the Laudolissin.

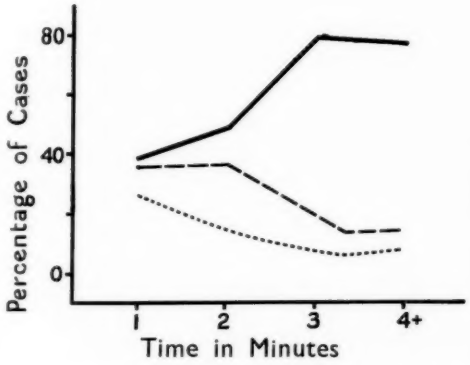

FIG. 2

Diagram illustrating the relationship of ease of intubation to the time after injection of Laudolissin. Percentage of cases is taken from table III.

——— easy intubation.
— — moderately easy intubation.
- - - - - difficult intubation.

(*b*) *Onset and duration of Apnoea and Relaxation.* In 172 cases, following doses adequate to produce paralysis of the respiratory muscles, apnoea occurred 2–3 mins. after the initial dose of relaxant, and persisted on the average for 35 mins. (range 10–60 mins.). The effect of the first supplementary dose (½–⅓ of original dose) persisted for about 1 hour (20–120 mins.), while the duration of apnoea following a third injection averaged 70 mins. (50–120 mins.). In abdominal cases it was frequently observed that a dose insufficient to produce complete apnoea afforded good relaxation. The respiratory excursion under these circumstances was inadequate with spontaneous respiration, but apnoea was remarkably easily induced by rhythmical inflation of the lungs.

Synergism and Antagonism. When spontaneous respiration became troublesome from the surgeon's point of view and it was undesirable to give more Laudolissin, as for example at the end of an intra-abdominal operation, advantage was taken of a very marked synergism between this relaxant and ether. A concentration of the latter, just detectable by smell, will prolong very considerably the period of apnoea and/or relaxation. This effect was more pronounced than when d-tubocurarine chloride was the relaxant in use. Similarly, prolongation of the relaxation could be achieved by quite small doses of gallamine triethiodide (10–20 mg.). It was an impression that both these effects seemed to be a true synergism rather than just additive.

As one might expect from the mode of action of these drugs (Collier, 1953), and the work of Davenport and McDonald (1953), small doses of suxamethonium tended to reverse the effects of Laudolissin (fig. 3). At least 50 mg. of suxamethonium were required before any increase in relaxation, or decrease in respiration occurred—a point which must be remembered when it is desired to use suxamethonium for closure of the peritoneum.

Antagonism by Neostigmine. It is impossible to agree with Bodman et al. (1952) that reversal of Laudolissin is always complete with neostigmine. The amounts of this drug given in 365 cases are shown in table IV. While the majority of cases reacted satisfactorily to a 5 mg.

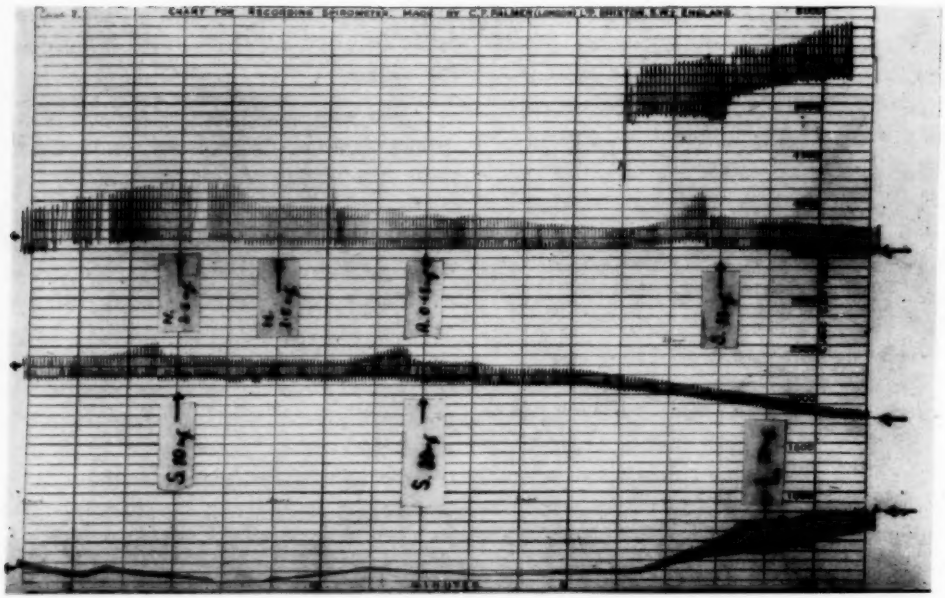

FIG. 3
Spirometric tracing showing antagonistic effects of small doses of suxamethonium to the respiratory depression caused by Laudolissin.
L = Laudolissin
S = Suxamethonium
A = Atropine
N = Neostigmine

TABLE IV

Dosage of neostigmine required for reversal of action of Laudolissin in 365 cases anaesthetized with thiopentone-nitrous oxide-oxygen with or without pethidine

Dose of neostigmine in mg.	No. of cases	Percentage
0	5	1.4
1.25	5	1.4
2.5	25	7.0
3.75	8	2.2
5.0	268	72.4
7.5	41	12.0
10+	13	3.6

dose or less, 15.6 per cent of these patients required more.

A phenomenon which has been observed on 6 occasions is a return of curarization when the patient goes back to the ward. In none of these was ether used. Apparently before leaving the operating theatre complete reversal of the effects of Laudolissin was obtained with 5 mg. neostigmine. Recurarization occurred 15–20 mins. after the neostigmine, and these patients who left the anaesthetic room with a good respiratory excursion were found in the ward to be very distressed with gasping respiration and a tracheal tug. The initial response to a further 2.5 mg. neostigmine with 0.65 mg. atropine was satisfactory, but in 2 cases this had to be repeated 25–30 mins. later. When this was necessary an intramuscular injection of 2.5 mg. neostigmine with 0.65 mg. atropine was also given and no further trouble occurred.

Dosage range. In 100 abdominal cases special observation was made of the dos-

age of Laudolissin required to produce satisfactory operating conditions. The anaesthetic combination used in these cases was thiopentone-nitrous oxide-oxygen, respiration being controlled throughout.

These cases bear sufficient similarity to a series published by Dundee (1952), in which d-tubocurarine chloride was used as the relaxant in place of Laudolissin, to enable a comparison to be made between the two drugs. Details of both series are given in table V.

TABLE V

Details of 200 cases anaesthetized with thiopentone, nitrous oxide and oxygen, in 100 of whom Laudolissin was the relaxant, and in the other 100 d-tubocurarine chloride was used

	Laudolissin	d-tubocurarine chloride
Number	100	100
Sex Incidence		
Males	63	70
Females	37	30
Average Age	47.7	46.9
Average Weight (kg.) ...	63.6	63
Operations		
Gastrectomy	64	65
Operations on bile ducts	11	10
Hysterectomy	7	6
Entero-anastomosis ...	4	5
Lumbar sympathectomy	4	4
Incisional hernia ...	3	5
Bilateral inguinal hernia	4	4
Colectomy	3	1
Total	100	100

The average dose of Laudolissin in mg./kg. required at 15 min. intervals for 2 hours is shown in table VI. This table also shows the average equivalent dose of a 10-stone subject and a comparison between the dosage of Laudolissin and d-tubocurarine chloride. A statistical analysis of the requirements of the two relaxants at 60, 90 and 120 mins. is given in table VII.

TABLE VI

Average dose of Laudolissin and equivalent dose for a 10 stone subject required by the 100 cases of Laudolissin listed in table V. A comparison is made with the requirements of d-tubocurarine chloride in a similar series of cases

	Dose of Laudolissin		
Time during anaesthesia	Dose mg./kg.	Equivalent for 10 stone subject	Relative potency to d-tubocurarine chloride
Induction	0.701	44.2	0.451
15 min.	0.753	47.4	0.554
30 ,,	0.824	52.2	0.580
45 ,,	0.890	56.0	0.586
60 ,,	0.933	58.8	0.585
75 ,,	0.976	61.5	0.588
90 ,,	1.005	63.3	0.587
105 ,,	1.014	63.9	0.594
120 ,,	1.022	64.4	0.593

An examination of the dosage of Laudolissin at the beginning of anaesthesia shows Laudolissin is less than half as potent a drug as d-tubocurarine chloride (fig. 4). At 30 mins. requirements of Laudolissin are just less than twice those of d-tubocurarine chloride and, as operating time proceeds, the ratio of doses of the two relaxants becomes slightly nearer unity. This is most likely to be due to the longer action of Laudolissin compared with d-tubocurarine chloride. The scatter of the dosage of Laudolissin required for anaesthesia lasting one hour is greater than that found with d-tubocurarine chloride, but by the end of another hour this value is the same for both drugs.

There was one case of sensitivity to Laudolissin in which diplopia and ptosis were very marked 1 min. after the test dose (10 mg.), the patient being unable to speak after 2 mins. Apnoea did not occur, but at the end of the operation, which lasted about an hour, the effect of this 10 mg. of the relaxant was not completely reversed by 5 mg. neostigmine.

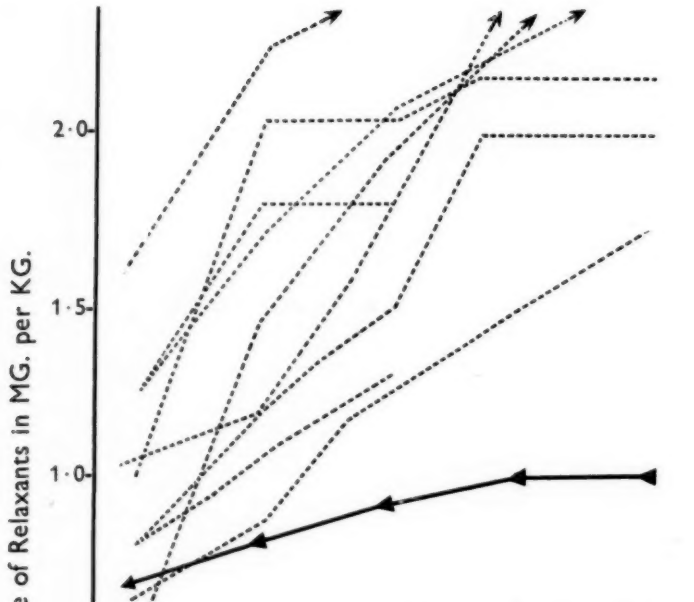

FIG. 4

Average requirements of Laudolissin and d-tubocurarine chloride for cases listed in table V, and individual requirements of Laudolissin in 9 cases of liver damage in which marked resistance to Laudolissin was encountered.

o——o d-tubocurarine chloride.

◂——◂ Laudolissin in normal cases.

- - - - - Laudolissin in cases of liver damage. In 4 of these the amount of Laudolissin eventually administered was outside the scale of the graph (indicated ↑).

TABLE VII

Statistical analysis of requirements of Laudolissin and d-tubocurarine chloride at 60, 90 and 120 minutes duration of anaesthesia in the cases listed in table V

Time during anaesthesia		Laudolissin mg./kg.	d-tubocurarine chloride mg./kg.
1 hour		0.933 ± 0.029	0.564 ± 0.013
	Standard Deviation	0.290	0.134
	Coefficient of Variation	32.0	22.0
1½ hours		1.005 ± 0.022	0.596 ± 0.013
	Standard Deviation	0.223	0.137
	Coefficient of Variation	22.7	24.1
2 hours		1.022 ± 0.024	0.605 ± 0.014
	Standard Deviation	0.244	0.146
	Coefficient of Variation	23.9	24.1

Nine cases of resistance to Laudolissin were encountered, individual requirements of these in mg./kg. being shown in figure 4. Varying degrees of liver dysfunction occurred in all of these patients, and, in 5 of them, the presence of a lowered serum cholinesterase was verified. The possible significance of this has been the subject of a recent communication (Dundee and Gray, 1953).

Circulatory and side effects, etc. Apart from the difficulty mentioned above, the operative conditions provided by Laudolissin were as good as one could have obtained with d-tubocurarine chloride. Similarly, the clinical condition of the patients was the same with both drugs. No abnormalities of blood pressure or pulse rate attributable to the relaxant occurred. There was no excessive salivation, and apart from one case of bronchospasm, there were no signs of any untoward action which might have been attributable to the Laudolissin. In the case of bronchospasm there was no history of asthma. The bronchospasm appeared after intubation, and persisted throughout most of the operation, some relief being obtained from two intramuscular injections, each of 0.5 ml. 1 : 1,000 adrenaline. There was no untoward reaction in this patient from the neostigmine at the end of operation.

DISCUSSION

It is re-emphasized that the purpose of this report is to compare Laudolissin with d-tubocurarine chloride, which, up to now, has been generally recognized as the most satisfactory long-acting relaxant agent. In the great majority of the cases under review, therefore, Laudolissin has not been combined with other relaxants. It is unnecessary to use more than one paralysant drug when d-tubocurarine chloride is employed, and if the use of Laudolissin entails the injection of more drugs, more ampoules to be opened, and more syringes to be prepared, it seems on *a priori* grounds a less useful product.

Laudolissin resembles d-tubocurarine chloride in that it always gives adequate muscular relaxation and control of the respiration; in the absence of side effects, circulatory and autonomic; in the fact that it can be reversed by neostigmine; and in that hypersensitivity and resistance to its effects may occur.

It differs from the curare alkaloid by virtue of:

(*a*) a slower onset of its action, and
(*b*) a longer duration of its effects.

The slower onset of paralysis can be a disadvantage during the induction of anaesthesia, if the relaxant agent is being relied upon to provide conditions for intubation. It need hardly be stated that, under these circumstances, the danger of regurgitation of stomach contents is greater. Another unfortunate result of this delay in onset was seen in one patient who became conscious after the preliminary administration of thiopentone during the necessarily prolonged inflation of the lungs with oxygen prior to intubation. This patient was actually conscious of the insertion of the endotracheal tube. Since this occasion, nitrous oxide and oxygen mixtures have been used for inflation and there has been no further similar occurrence. In regard to intubation, it has not been possible to confirm the observation of Bodman, Morton and Wylie (1952) that Laudolissin fails to relax the laryngeal muscles. In this respect, given time, it seems to be identical with d-tubocurarine chloride. The slower onset of the effects of Laudolissin was not apparent when successive maintenance doses were given during anaesthesia.

The longer duration of the effect of Laudolissin has been obvious during this series (table VII). This may be used advantageously when it is convenient only to give a single dose of relaxant agent, as in gynaecological anaesthesia or in private nursing homes. Used in this way in moderate dosage (40–50 mg.) Laudolissin has undoubtedly provided ideal conditions. It is not necessary to supplement it with a dose of short-acting relaxant to close the abdomen, as its ready and marked potentiation by ether can be turned to advantage for this purpose. Nevertheless, this prolonged action can be the source of troubles. A laparotomy, or indeed any operation, may be completed rather more quickly than was expected, and this may result in a considerable delay in the resumption of an adequate degree of spontaneous respiration to permit the administration of neostigmine. A further and disturbing aspect of the long action of the drug is that its effects may outlast the effects of neostigmine given at the end of anaesthesia. The occurrence of recurarization after return to bed, which has been seen in 6 instances during this series, has been particularly disturbing.

Quite apart from recurarization, the experience gained during this trial has been sufficient to justify the statement that the reversal of the effects of Laudolissin by the usual dosage of neostigmine is likely to be less complete than is seen with d-tubocurarine chloride. This observation is confirmed by Rizzi and Ricci (1953).

CONCLUSIONS

In view of its prolonged effect and the occasional inadequacy of its reversal by neostigmine, Laudolissin cannot be considered as a completely satisfactory substitute for d-tubocurarine chloride in general anaesthetic practice. Its long action may be put to good purpose on occasions when it is undesirable to give repetitive intravenous injections. The fact that it is synthetic, and effective dose for effective dose considerably less expensive than d-tubocurarine, will be an attraction,

although it is emphasized that those who use it must be prepared to deal with the difficulties that have been described.

SUMMARY

1. A clinical trial of Laudolissin has been undertaken in 524 cases.

2. It has been compared with d-tubocurarine chloride in respect to the time of onset, its duration of action, the ease of intubation, its dosage, and its synergisms and antagonisms.

3. It is considered, as a result of the observations made during this trial, that Laudolissin is not a perfect substitute for d-tubocurarine chloride.

4. It is suggested that its main use will be for cases in which it is inconvenient to give repetitive intravenous injections.

ACKNOWLEDGMENT

We would like to express our gratitude to Messrs. Allen and Hanburys Ltd., who have so generously supplied the Laudolissin which has been used in this trial.

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BOOK REVIEW

Cahiers d'Anesthésiologie. Edited by E. Kern, J. Lassner and J. Valletta. Published by Editions de Minuit, Paris.

These notes, the first of which appeared in April 1953, are written for the sake of those doctors who, by reason of distance or time, are unable to attend the Wednesday conferences. These are held every Wednesday afternoon at the Clinique Chirurgicale Orthopédique et Reparatrice de l'Hôpital Cochin. They have been organized by Drs. Kern and Lassner. Cases are reviewed and papers read and discussed. The conferences provide opportunities for the teachers to teach, and as there is no better way of finding out what you do not know about a subject than by teaching it, so these meetings will perfect the instructors' knowledge and will afford opportunities for non-specialists to get acquainted with the best practice.

Two of the papers in the present volume "La physiologie de la curarisation" and "Considerations sur la douleur et sa suppression" are of first class interest, and both the other two and the "Observations communities" will well repay the time spent on their perusal.

These discussions are likely to result in a raising of the general level of ability of the medical men who are so fortunate as to be able to attend them.

Brit. J. Anaesth. (1954), **26**, 22.

THE EFFECTS OF N-ALLYLNORMORPHINE ON HEALTHY SUBJECTS PREMEDICATED WITH MORPHINE

BY

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THE advantages of a specific antidote to morphine are self evident. In 1941, McCawley, Hart and Marsh synthesized N-allylnormorphine, a compound closely related to morphine but differing in that the N-methyl group of morphine had been replaced by an N-allyl group. Its antagonistic effects to morphine in experimental animals have been described by several authors, particularly by Unna (1943), and Hart and McCawley (1944). Since 1951, favourable reports have been published of its use in man by Eckenhoff, Elder and King (1951, 1952), Eckenhoff, Hoffman and Dripps (1952), Wikler (1951) and Fraser, Wikler, Eisenman and Isbell (1952).

More recently, it has been suggested (Keele, 1953) that the drug might be used in man to terminate the central depression produced by morphine within the therapeutic range. Obviously, such a property would be of considerable value to anaesthetists in the management of anaesthesia for outpatients, and it was with this purpose in view that the following investigation was undertaken.

METHOD

The drug was first investigated in a group of outpatients (Group I). Three patients about to undergo cystoscopy were given 15 mg. (gr. $\frac{1}{4}$) of morphine intravenously 15 min. before the examination was begun. Cystoscopy was then carried out without anaesthesia and, on its completion, 10 mg. of N-allylnormorphine were given intravenously. One other outpatient was given 15 mg. (gr. $\frac{1}{4}$) of morphine intramuscularly 30 min. before the administration of nitrous oxide and oxygen anaesthesia for minor surgery. On recovering consciousness he was given 10 mg. of N-allylnormorphine intravenously. The patients were observed for a varying period from 1 to 6 hours after the injection. Because of the prolonged and unpleasant sequelae, this group was limited to these four patients.

Further investigations were then carried out on a group of seven healthy young adult males between the ages of twenty and thirty-two (Group II). For the duration of the experiment each subject was recumbent. The resting respiratory rate, tidal air and minute volume were recorded using a Benedict-Roth spirometer. The blood pressure and pulse rate were measured routinely. Morphine 15 mg. was then given intramuscularly or intravenously and 30 min. later the respiratory measurements were repeated. As the tracings were being recorded, 10 mg. of N-allylnormorphine were given intra-

venously and the record continued for at least 15 min. after the injection.

RESULTS

In Group I, three of the four patients became very drowsy a few minutes after the injection of N-allylnormorphine and two of them had to be detained in hospital because of their inability to remain awake. Pallor of the face, accompanied by profuse sweating and nausea, was obvious in all three, and vomiting occurred in the two patients who were detained. In the fourth patient no clinical effects were noted.

In Group II, the findings were comparable. Respiratory minute volumes were measured in six of the seven subjects and the results are shown in Table I. In five of the six subjects, the minute volume was reduced following the injection of morphine. Almost immediately after the injection of N-allylnormorphine, the minute volume increased in all cases. The effect, however, was not sustained and within 10 min. had fallen to below the

TABLE I

Minute volume in litres

Subject	Control	30 min. after morphine	2 min. after N-anm.	10 min. after N-anm.
J D F	11.1	8.0	13.5	8.0
S L G	12.8	14.4	20.1	8.4
V L	12.7	6.2	10.4	*
D P	12.2	9.8	12.9	10.7
B C	10.6	7.9	16.4	14.5
J B S	11.8	10.2	12.8	9.0
Mean	11.9	9.4	14.4	10.1

* Cheynes-Stokes breathing developed.

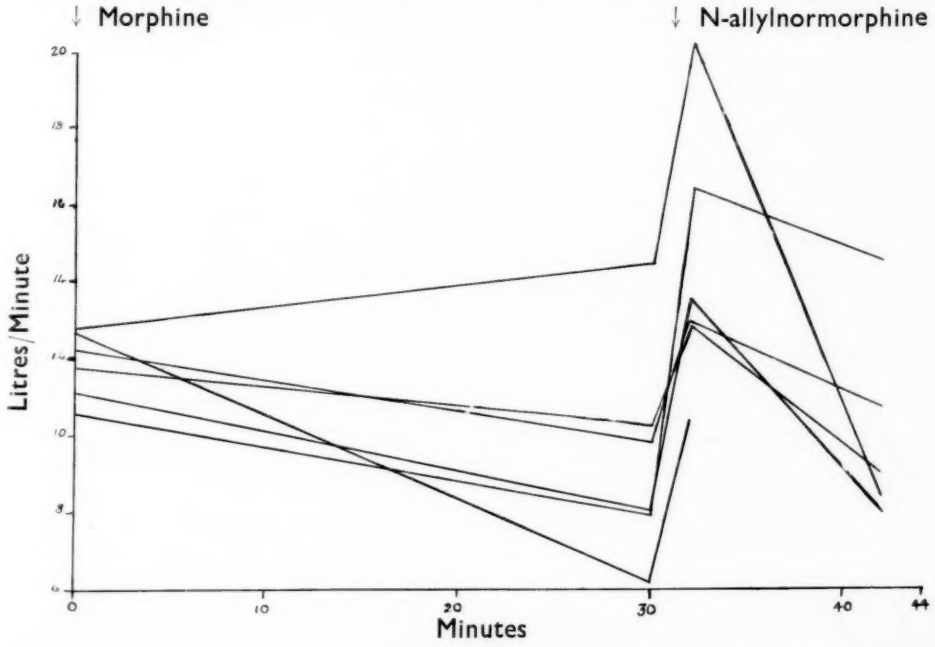

FIG. 1

Changes in minute volume in six subjects following the injection of
(1) 15 mg. morphine
(2) 10 mg. N-allylnormorphine

control level. In one subject Cheynes-Stokes breathing developed at this stage and lasted for 4 minutes. The changes in the minute volumes are shown in figure 1.

Drowsiness, however, was the outstanding effect produced by N-allylnormorphine. It began soon after the injection of the drug and lasted for several hours. All subjects had difficulty in remaining awake and several fell asleep during conversation. Pallor of the face was present in every subject but a fall in blood pressure was noted in only one. The fall from 130/75 mm.Hg to 110/70 mm.Hg was accompanied by a decrease in pulse rate from 68/min. to 52/min. Six of the seven subjects complained of nausea and of these, three vomited. Sweating occurred in four subjects, being particularly obvious on the forehead, palms of hands and feet, though not confined to these regions. The dysphoria described by Wikler (1951) was not apparent.

A quantitative assessment of these effects was not undertaken, but the distribution can be seen in Table II.

TABLE II

Side effects produced by 10 mg. of N-allylnormorphine in eleven subjects previously given 15 mg. of morphine

Subject	Hypnosis	Nausea	Vomiting	Sweating	Pallor	Vertigo
Group I						
A B	+	+	+	+	+	+
A R	—	—	—	—	—	—
W B	+	—	—	+	+	+
W G	+	+	+	+	+	+
Group II						
J P P	+	+	+	+	+	—
B C	+	+	+	—	+	+
R P	+	+	—	+	+	—
T B S	+	—	—	+	+	+
V L	+	+	+	—	+	+
S L G	+	+	—	+	+	+
J D F	+	+	—	—	+	—

DISCUSSION

It is apparent from the evidence presented that N-allylnormorphine is unsuitable for use in the management of anaesthesia for outpatients. No analeptic effect could be demonstrated while the hypnotic and emetic actions of the drug were definite deterrents to its use.

Although no attempt was made to measure the degree of hypnosis quantitatively, it can be said that it was considerably greater following the injection of N-allylnormorphine than after morphine alone, when the extent of depression was insignificant. This degree of drowsiness was not anticipated. Previous work (Eckenhoff, Hoffman and Dripps, 1952) had suggested that, while the awakening action of N-allylnormorphine was slight, there was little evidence to indicate a specific hypnotic effect on the part of the drug. On the other hand, Eckenhoff, Elder and King (1951) have reported that in a group of volunteers given from 5 to 10 mg. of N-allylnormorphine intravenously, all the subjects complained of "a tired feeling".

The mechanism of this action is not clear, but it is possible that the excessive drowsiness is a summation of the sedative effects of morphine and N-allylnormorphine. Alternatively, these drugs may have a reciprocal potentiating effect on each other.

Although vomiting occurred in only five of the eleven subjects, nausea was present in eight and these effects were obvious for some hours. Again it may be suggested that these results are a consequence of a summation or potentiation of the actions of the two drugs.

The only evidence in favour of

morphine antagonism is the stimulation of respiration which occurred following the injection of N-allylnormorphine. This effect, however, was a transitory one and within 10 min. the minute volume had fallen to a level below that of the control in five out of the six subjects. Possibly, had the dose of N-allylnormorphine been increased, the stimulation might have been prolonged, but at the same time, it is worth remembering that when animals die from the effects of the drug, death is due to respiratory failure (Unna, 1943).

Although this is a short series of cases, there is sufficient evidence to suggest that the antagonism of N-allylnormorphine to morphine is a limited one, and that, within the therapeutic range at least, the hypnotic and emetic effects are likely to preclude its use.

SUMMARY

1. The clinical effects of N-allylnormorphine on 11 persons previously premedicated with morphine were investigated. In 7 of them the effect of the drug on the respiratory rate, tidal air, and minute volume was observed.

2. No marked antagonism to morphine was noted, except a transient stimulation of respiration.

3. Many of the effects observed were both unpleasant and prolonged.

4. There was no evidence to justify the use of N-allylnormorphine in the management of anaesthesia for outpatients.

ACKNOWLEDGMENTS

I am indebted to Dr. H. J. Brennan who first suggested this investigation.

I would also like to express my thanks to the to the volunteers who made it possible.

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HYPOTENSION INDUCED WITH HEXAMETHONIUM BROMIDE DURING ANAESTHESIA

BY

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IN 1950 and 1951 accounts were published of lowering the blood pressure of patients during surgical operations by the intravenous injection of methonium compounds with significant reduction in blood loss (Enderby, 1950; Enderby and Pelmore, 1951). We were trying to achieve the same result at that time by epidural sympathetic block. The methonium compounds offered a simpler means and we started using them in the way which he had described. We are here presenting a consecutive series of 442 patients, operated upon between July 1951 and July 1953, in an attempt to assess the usefulness and safety of this method during anaesthesia.

SELECTION OF PATIENTS

Table I shows the age groups of the patients in this series and the operations that were performed. The guiding principles in choosing the patients have been:

A. Patients to whom a blood transfusion would normally be given during the proposed operation.

There is a considerable variation in the indications accepted by surgeons and anaesthetists for transfusion. We believe that blood loss is the main cause of shock during the operative period, and it was our practice to transfuse all patients who were likely to develop signs of shock during or after operation. We had been

TABLE I

Age distribution of patients and operations performed

Age group years	Mastectomy	Prostatectomy	Colon and rectum	Miscellaneous gen. surgical	Judet arthroplasty	Spinal fusion	Arthrodesis of hip	Pin and plate femur	Capsular tear shoulder	Miscellaneous orthopaedic	Hysterectomy	Pelvic floor repair	Totals
1 — 10							3			2			5
11 — 20				2	5	4	10	1		9			31
21 — 30			2	6	5	10	1		2	12		3	41
31 — 40	2			10	4	13	5		1	12	10	18	75
41 — 50	11			14	13	10	1		3	10	16	13	91
51 — 60	3	3	5	9	14	5			2	6	6	25	78
61 — 70	2	8	3	2	26			1	3	3	4	19	71
71 — 80	1	7		5	16			3		1	1	1	35
Over 80		2			5			6		1		1	15
TOTALS	19	20	10	48	88	42	20	11	11	56	37	80	442

giving blood to most patients undergoing major orthopaedic operations in which a tourniquet could not be applied, to most cases of hemi-colectomy, excision of rectum, prostatectomy, panhysterectomy, radical mastectomy, and to many others. We were using a considerable amount of blood. In this series blood was given only to correct a pre-operative anaemia of less than 75 per cent Hb.

B. Patients upon whom an operation was proposed which would be made longer and more difficult by bleeding.

Judgement also varies among surgeons and anaesthetists on this matter. The surgeon merits all the help that can be vouchsafed to him with safety to the patient, not only for his convenience, but also because the patient may thereby have a more successful operation performed. It can be very difficult to identify an intervertebral disc when the epidural veins are bleeding freely; bleeding round the shoulder joint can make the accurate suture of a capsular tear very awkward.

Table II shows the age groups of the patients and their pre-operative blood pressure groups. The principal danger that has been ascribed to medication with

TABLE II

Age distribution of patients and pre-operative blood pressure groups

Age group years	130/90 or lower	Between 130/90 and 200/100	Above 200/100	Totals
1 — 10	5			5
11 — 20	31			31
21 — 30	39	2		41
31 — 40	58	16	1	75
41 — 50	56	32	3	91
51 — 60	26	43	9	78
61 — 70	13	34	24	71
71 — 80	3	22	10	35
Over 80	2	7	6	15
Totals	233	156	53	442

methonium compounds is associated with the cardio-vascular system (Hayward, 1952). It seemed to us that the clinical condition of anaesthetized patients with induced hypotension was excellent; we reflected that for many years patients with severe hypertension and associated cardio-vascular changes had survived radical sympathectomies of the Smithwick type causing gross reduction of blood pressure. We therefore assessed the state of the cardio-vascular system in our patients, but did not in any case withhold induced hypotension because of cardio-vascular disease.

It is not suggested that a blood pressure reading gives a complete picture of cardio-vascular health or disease. It is used here as a means of indicating quickly, in conjunction with the age groups, the proportion of these cases which had pathological cardio-vascular systems. The vast majority of those with normal blood pressures may be assumed to have healthy vessels, those with moderately raised blood pressures to be showing some signs of wear, and those with grossly raised pressures to be in the category of poor operative risks. These last include patients with a previous coronary or cerebral occlusion, with heart block, auricular fibrillation and cardiac decompensation.

TECHNIQUE

Anaesthesia.

Various anaesthetic techniques have been used in these cases. The intention throughout has been to maintain a clear airway, full oxygenation, spontaneous breathing and a minimal depth of anaesthesia. Pre-operative morphia or Papaveretum (Omnopon) has not been used, in order to avoid prolonged depression of the

respiratory centre: a rise in arterial carbon dioxide tension raises the blood pressure and increases bleeding even when a block of the sympathetic ganglia has been established. Premedication has therefore been with atropine only. Induction has normally been by a mixture of thiopentone and gallamine triethiodide followed immediately by the first dose of hexamethonium bromide through the same needle. The patient has then been intubated and maintenance has been with nitrous oxide-oxygen-trichlorethylene, with nitrous oxide-oxygen-pethidine or with cyclopropane, additional gallamine being given as required. An intravenous drip is started after the patient has been placed in position on the operating table. This is an important safeguard because subsequent intravenous injections can be given promptly and with certainty.

Control of blood pressure.

We try to keep the systolic blood pressure at a level at which bleeding is satisfactorily reduced, but at which the patient's well-being is safe-guarded. No absolute level which invariably fulfils both these criteria seems to exist. All pressures given here are systolic taken with a cuff on the brachial artery and gauged by palpating the radial artery. We have found auscultatory methods in the theatre difficult, diastolic pressures in particular being impossible to ascertain with regularity during periods of hypotension. Likewise, the method of determining the systolic pressure by watching the oscillations of the manometer needle has not proved satisfactory in our hands. Serial blood pressure recording is not essential during the operation, because an exact predetermined level cannot be maintained and is not necessary. The state of the patient and the adequacy of the dosage can be judged by the colour of the skin, palpation of the pulse, the character of the respirations and the amount of bleeding in the wound.

Our criteria for excessive hypotension are:

A. No palpable radial pulse for ten minutes.

B. Any suggestion of cyanosis.

In either case an intravenous drip consisting of 30 mg. of methylamphetamine (Methedrine) in 500 ml. normal saline, is started at the rate of 100 drops per minute and continued until the pressure is raised to 50 mm. Hg or until the cyanosis has disappeared.

Dosage of hexamethonium and use of procaine.

The doses stated here are weights of hexamethonium bromide. They are administered intravenously in a 10 per cent solution. The effect of a given dose cannot be foretold with certainty. Occasionally a small dose will produce a profound hypotension or a large dose a relatively slight effect. It is easier to raise a blood pressure that has dropped too far, than to reduce a blood pressure that is reluctant to drop. We now give an initial dose of 300 mg. to patients between 10 and 70 years of age. For a child below 10 years old the dose is proportional to its size. To those between 70 and 80 years of age 200 mg. are given, and to those over 80 years of age 100 mg. This dose is repeated during the early part of the operation if the blood pressure is above 70 mm.Hg and bleeding is more than usual. The second dose rarely produces a profound drop in

pressure and, when it does, such a fall is usually transient. Should the pressure remain above 70 mm.Hg and bleeding continue, even after the second injection, an infusion of 0.4 per cent procaine is started at a rate of 150 drops per minute. It is safe to give one gramme of procaine intravenously in this way in half an hour with a maximum dosage of 2 g., and in this dosage procaine will lower the blood pressure and reduce bleeding. Lignocaine (Xylocaine) in 0.25 per cent solution may be substituted at a maximum rate of one half gramme in half an hour, with a maximum dosage of one gramme, with equal effect. Alternatively, procaine amide may be injected in single doses of 500 mg. at intervals of not less than five minutes; the maximum dose used in this series has been one and one half grammes. The effect is less marked, not usually being noticeable in dosage of less than one gramme, and there is not the same minute to minute control.

Posture.

Posture plays little part in our technique. Operations on the limbs are done with a tourniquet. We have not been concerned with brain surgery. In thyroid operations and in dissections of cervical glands some degree of elevation of the head may be permitted if there is much bleeding. We do not persist with elevation to the point at which the field becomes completely " bloodless " because it seems to us that the cerebral circulation must then become imperilled. It is safer, in our opinion, to try and obtain a satisfactory reduction of bleeding by adequate hypotension in the horizontal position with larger doses of methonium combined, if necessary, with intravenous procaine. It can be argued that a head-down position might be dangerous owing to a gravitational passive congestion of the cerebral vessels. Most of the hysterectomies were done in a 25°–30° head down position. No congestion of the skin of the face was detected; the retinal vessels were not engorged; respiratory rhythm was unaffected. Such changes would have been expected were this argument valid. We confirm the finding of Lipton (1950) that the knee-chest position during lamin-

TABLE III

Showing age groups, lowest recorded blood pressures, procaine and procaine amide administrations and cases in which control of bleeding was poor

Age group years	No palpable radial pulse	50 mm. Hg. systolic or lower	Above 50 mm. Hg. but not above 70 mm. Hg. systolic	Above 70 mm. Hg. systolic	Totals	Poor control of bleeding	Intravenous procaine	Intravenous procaine amide
1 — 10		1	3	1	5			1
11 — 20	4	14	9	4	31	2	4	4
21 — 30	7	8	18	8	41	1	6	8
31 — 40	9	11	37	18	75	4	11	8
41 — 50	10	20	48	13	91	4	11	9
51 — 60	12	14	44	8	78	1	6	9
61 — 70	17	10	32	12	71	2	5	4
71 — 80	9	8	14	4	35		4	1
Over 80	5	3	5	2	15		2	1
Totals	73	89	210	70	442	14	49	45

ectomies, by reducing the "back pressure" in the epidural veins, is of the greatest assistance in overcoming the very troublesome bleeding which they can produce.

Table III summarizes the lowest recorded blood pressure in patients in the different age groups and shows the number of cases in which procaine and procaine amide were used.

EFFECT OF HYPOTENSION DURING OPERATION

The hypotensive patient has a dry, pale skin; the nail beds and ears are pink. The breathing is regular; the pulse is also regular and, after procaine, slow; the capillary refill time is short.

Without induced hypotension there is the widest possible variation in the quantity of blood lost by different patients undergoing the same operation even when performed by the same operating team. It is not easy to assess with certainty the actual loss that occurs in an operation. Ideally the blood can be measured. This ideal is beyond the facilities at our disposal. The number of swabs used can be counted, but the figure is most deceptive, since a soaked swab accounts for no more than one with a single small blood stain; and what of the collection in a receiver?

It is therefore very difficult to assess the degree of reduction in bleeding due to hypotension in a given case. We have found that with adequate hypotension capillary oozing and venous bleeding are negligible, provided there is no venous obstruction. A medium sized artery bleeds freely when cut, but instead of sending quite a high spurt the flow rises two or three inches. Such vessels are clamped. The cut skin shows bleeding points as usual, but if these are left alone no further blood pours out to form a pool in the wound; muscle stripped off bone is covered with a film of blood but there is no steady drip on to the floor of the theatre; cut bone is moist with blood but it does not well up as from a spring. When the haemoglobin level, five days after a big operation, is 10–15 per cent lower than pre-operatively, the drop in a similar operation without hypotension and without transfusion is of the order of 40–50 per cent. After a spinal fusion we have the impression that a quarter to half a pint of blood has been shed; previously we gave these cases a transfusion of two pints of blood. Exceptionally there may be literally no blood seen at all, a pelvic floor repair finished and only a single swab slightly tinged. Such a bloodless field is rarely produced (except with considerable elevation of the operative part), is never necessary and very possibly is not safe.

Bleeding was satisfactorily controlled in the vast majority of cases, poor control being noted during only 14 of the 442 operations.

POST-OPERATIVE COURSE

Hypotension, unless combated, persists post-operatively for varying periods. Exceptionally the pressure may return to normal in a few minutes; or it may remain low for more than twenty-four hours. The majority of cases are stable after eight hours. We consider it desirable to raise the pressure to normal limits at the end of the operation, and effect this by giving an intravenous drip consisting of methylamphetamine (Methedrine) 30 mg. in 500 ml. of normal saline, the rate of the drip being adjusted as indicated by

the pressure. The effect of methylamphetamine given in this way lasts for about half an hour after its administration is stopped. In practice the drip is progressively slowed, normal saline being substituted for the methylamphetamine when the pressure seems to be stable, and the drip is discontinued when the pressure has been steady for more than an hour without methylamphetamine. Typically the drip can be taken down after eight hours, the usual total dose of methylamphetamine being 30–60 mg.

Wyman (1953) found that methylamphetamine caused sleeplessness and harmful mental stimulation. There is a central as well as a peripheral effect of methylamphetamine, but when administered in the way described sleeplessness occurs in only very rare instances. Wyman (1953) also found that when the blood pressure is raised by single doses of methylamphetamine collapse frequently occurs a short time later. We regard this so-called collapse as the end of the action of the dose given. When methylamphetamine is administered in a drip collapse is avoided, the minimum dose required is given and its effect is continued until the autonomic nervous system has returned to normal. Methylamphetamine is a very powerful drug; 5 mg. injected intravenously can raise the blood pressure 150 mm.Hg. Stimulation of such intensity is surely not without danger. It should be used intravenously only in extreme dilution because then there is a gentle, continuing effect and a wide margin of safety. The management of the drip can be left to a nurse who has been instructed in the method and keeps a half-hourly blood pressure chart.

OPERATIVE MORTALITY AND MORBIDITY

Nine patients in this series of 442 died during the post-operative period. One death was directly attributable to faulty technique in an early case. A healthy man of 75 years had a prostatectomy. The blood pressure did not rise above 70 mm.Hg during the first 36 hours. A methylamphetamine drip was then started and the pressure rose to normal. Gross mental changes had occurred however, and death took place two months later of anorexia and toxaemia from a large bedsore. This occurrence was entirely preventable, and since this case we have always taken active steps to raise the blood pressure at the end of the operation. Renal anoxia has been suggested as a possible danger during hypotension. It may be worthy of note that in this case there was no evidence of renal damage in spite of the prolonged severe hypotension.

Details of the eight other patients are as follows:

(1) An emaciated woman of 68 years weighing 5 stone (32 kg.) had an exploratory thoracotomy and laparotomy for an oesophageal stricture. She had undergone a partial gastrectomy a year previously for a duodenal ulcer. The stricture was found at the level where the oesophagus crosses the aorta, and the attempt to treat it surgically was abandoned. A gastrostomy was performed. She died three days later apparently from pneumonia and inanition. No post-mortem examination was made.

(2) A woman of 58 years died of a coronary occlusion 19 hours after a radical mastectomy. Coronary disease had not been suspected pre-operatively. She was an early case in the series and

had received only 35 mg. of hexamethonium bromide. Her pre-operative blood pressure of 130/80 dropped to 50 mm.Hg and bleeding was satisfactorily controlled throughout the operation. Two intramuscular injections of 4 mg. of methylamphetamine were given towards the end of the operation. No drip was used during or after the operation. The blood pressure was 120/70 when she returned to the ward and she remained well until her sudden terminal collapse. The cause of death was proved at post-mortem examination. We find it difficult to believe that the period of hypotension could have caused a coronary catastrophe nineteen hours subsequently.

(3) A man of 72 years was admitted with acute retention following frequency and difficulty of micturition of several years' duration. The bladder was grossly distended; the blood urea was 35 mg. per cent. He was treated by an in-dwelling catheter for 5 days and then by a retro-pubic prostatectomy, a large adenomatous gland being removed. The pre-operative blood pressure of 160/90 was lowered by 200 mg. of hexamethonium bromide to 70 mm.Hg. After operation the blood pressure remained above 100/60 during the first five hours and above 120/80 subsequently. The methylamphetamine drip was continued for 18 hours. The patient secreted no urine and died 36 hours later. An exhaustive post-mortem examination demonstrated no cause of the anuria and revealed no lesion of the kidneys, heart or brain that could be associated with the hypotension.

(4) A woman of 60 years had an abdomino-perineal resection of the rectum. A month previously she had developed an acute obstruction which was relieved by colostomy. Wide-spread peritonitis was present at that time. After the resection she developed a severe paralytic ileus, her blood urea mounted and she died in uraemia two weeks later. Post-mortem examination showed unhealthy kidneys and metastases.

(5) A man of 77 years started vomiting on the day after a Judet arthroplasty. He was thought to have an acute dilatation of the stomach and was treated with gastric aspiration and intravenous infusion. He died on the fifth post-operative day. Post-mortem examination showed a fatty heart, pulmonary oedema, a dilated, empty stomach and generalized arterio-sclerosis.

(6) A woman of 72 years, following a pan-hysterectomy for carcinoma of the body, had a low grade pyrexia unaccompanied by physical signs and apparently unaffected by antibiotics. On the sixteenth post-operative day she had a massive pulmonary embolus. No post-mortem examination was made.

(7) A man of 75 years with a long history of urinary symptoms, chronic bronchitis and mild heart failure had a one-stage transvesical prostatectomy. Post-operative oliguria persisted and he died one week later apparently of renal failure. No post-mortem examination was performed.

(8) A man of 83 years had a one-stage transvesical prostatectomy. Post-operatively he developed acute bronchitis, left lower lobe pneumonia and died 2 weeks later from heart failure. Urinary secretion was satisfactory. No post-mortem examination was performed.

These 8 deaths probably all

occurred as the result of the patient's disease or of well-known complications of operation. They took place a considerable time after the hypotensive period; there was little similarity between the features they presented and no evidence was found to convince us that hexamethonium bromide played any part in the fatal outcome.

No untoward reactions due to hypotension have been encountered; cerebral thrombosis has not been a complication. We have not observed the changing colour of the liver surface when the blood pressure falls below 60 mm.Hg which has been described by Bromage (1952).

We have found no pathological condition which contra-indicates the use of hexamethonium bromide. In our experience, patients with cardio-vascular disease tolerate this technique very well. Electro-cardiograms which we have taken before, during and after operations on patients with known heart disease have shown no changes due to the methonium compound; even when the blood pressure has been below 50 mm.Hg in the brachial artery no evidence of cardiac ischaemia was demonstrated.

"Reactionary haemorrhage" has not occurred in our series. The incidence of haematoma formation after orthopaedic operations is unchanged. No serious haematoma has occurred after a pelvic floor repair.

Haemorrhage from medium sized arteries can occur. During the anastomosis stage of a partial gastrectomy a patient became blanched and the blood pressure unexpectedly dropped and did not immediately respond to methylamphetamine. The surgeon was asked to look under the packs and a large accumulation of blood was found in the peritoneal cavity. Another patient, six hours after a hemi-colectomy, became grey in colour with a moist skin and some dyspnoea. The blood pressure, which had risen with the routine methylamphetamine drip, was found to be dropping. A transfusion was started and after two bottles of blood had been given her condition returned to normal. The signs of bleeding are not obscured by ganglionic blockage nor are the principles of its treatment altered.

Except in the two cases in which bleeding occurred none of these patients developed signs of shock during operation or in the post-operative period.

DISCUSSION

Many possible dangers of reduced blood pressure have been suggested since hypotensive techniques have been used during anaesthesia. It has not always been remembered that major surgery in the past has frequently caused severe shock and that even today this can still occur. The blood pressure in shock may be so low as to be unrecordable; there is a reduction in circulating blood volume and vaso-constriction which causes tissue hypoxia. This can be seen in the cyanosed extremities. Contrast this condition with that of the patient with hypotension induced with the methonium compounds where a reduced peripheral resistance permits an adequate flow of blood to the tissues, as may be demonstrated by the pink extremities and the good colour of the organs exposed during operation. The catastrophes for which induced hypotension has sometimes been held responsible

were not previously regarded as sequelae of shock: yet the hypotension of shock would appear to be potentially of far greater danger than that of sympathetic ganglion block.

In our experience hypotension produced in the manner described is a valuable aid to anaesthesia and surgery. Blood loss is reduced to the extent that replacement by transfusion is hardly ever needed. Shock is avoided. Operating time is shortened and some technically difficult operations made easier. The post-operative condition of the patients is very good; better than when after similar operations considerable blood loss has been replaced by adequate transfusion. The greater the blood loss normally associated with an operation the greater the benefit of this method; in this type of operation the patient who is least fit to withstand the assault is most obviously helped through his ordeal.

Mortality and morbidity must be carefully watched in assessing a new technique. We believe that the troubles which have been described in papers and at discussions on hypotension are related to the administration of the anaesthetic and not to the pharmacological effect of the methonium compounds. These drugs do not make anaesthesia easier; they can, however, help by extending the range of surgery. They do not of themselves confer safety any more than do cyclopropane or thiopentone or curare, but as with these substances they can play a part in increasing the safety of a patient submitted to operation.

ACKNOWLEDGMENTS

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CASE REPORT

A FATAL CASE OF POST-OPERATIVE OBSTRUCTIVE TRACHEITIS

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FOLLOWING the interesting report of pressure necrosis of the laryngeal mucosa due to the use of a cuffed tube (Belam and Zuck, 1953) we have encountered a most extraordinary fatal respiratory obstruction in which the use of a cuffed tube appears to have been the precipitating cause.

A fit, well-nourished Kurdish woman, aged twenty-two, had suffered a punitive amputation of the nose and had come to Baghdad for plastic surgery. She was free from respiratory infection and coryza. A forehead rotation flap was raised and a first stage reconstruction of the nose carried out with the use of diathermy on June 1, 1953.

She was given intravenous atropine gr. 1/100 (0.65 mg.) with morphia gr. 1/6 (10 mg.) followed by thiopentone 0.5 g. and suxamethonium chloride 50 mg. A cuffed endotracheal tube size No. 7 was passed and anaesthesia maintained with air, oxygen and trichlorethylene. Supplementary doses of thiopentone totalling 0.5 g. and pethedine 100 mg. were given during the operation which lasted one and three-quarter hours. The patient was in light anaesthesia at the end of operation and coughed on extubation. Anaesthesia was quite uneventful and the inflation of the cuff was effected by tactile impression of the tension in the pilot balloon.

The patient made a good recovery and had no hoarseness post-operatively. On the second day (June 3, 1953) whilst walking in the garden, she noticed some difficulty in breathing and retired to bed after lunch. She became progressively dyspnoeic during the afternoon and by 4 p.m. was cyanosed. No physical signs were found in the chest and oxygen by nasal catheter and injections of aminophylline failed to relieve the cyanosis. Dyspnoea was extreme by 8 p.m. and the patient became unconscious. Although the resident staff had prepared instruments for tracheotomy, this operation was not undertaken as the pathology was thought to be probably intrathoracic.

When examined at 8.30 p.m. the patient was found to be deeply unconscious with fixed central and widely dilated pupils. There was no response to painful stimuli. Gross inspiratory obstruction with marked activity of the accessory muscles was present and the volume of tidal air was probably between 50 and 100 ml., that is, barely audible. Obstructive wheezing could be heard over the trachea. Although she was receiving pure oxygen by face-piece, her colour was

dusky, but not completely cyanotic. The pulse, blood pressure and cutaneous circulation were good. No very definite signs were present in the chest and there was no mediastinal shift.

Except for some mandibular spasm, there was no difficulty in laryngoscopy. The glottis appeared normal and the cords were widely abducted and below them were some white matter and what appeared to be solid red membrane. A well lubricated endotracheal tube No. 5 passed down the trachea with only slight difficulty and after reaching 2.5 in. below the cords the respiratory obstruction was suddenly relieved and the forcible inspiratory efforts resulted in violent hyperpnoea, which continued for ten minutes. During this time the patient's reflexes began to return, eyeball activity, lid reflex and spontaneous movements occurred. Much fluid was aspirated by catheter through the tube. The pharynx and glottis were cocainized preparatory to bronchoscopy and upon removal of the endotracheal tube inspiratory obstruction returned, but less severe than before.

Immediately below the cords the appearance of redness was found to be due to gross inflammatory swelling of the tracheal mucosa which lay in folds presenting an appearance similar to the oesophagus. No tracheal rings were visible and the bright red folds of mucosa were wet with mucus. After the bronchoscope had penetrated nearly 2.5 in. below the glottis there was a certain resistance to further introduction, presumably by the inflammed oedematous tracheal mucosa. The carina was faintly visualized as a red median partition.

Upon withdrawal of the bronchoscope inspiratory obstruction was only slight and the patient had regained consciousness and, in reply to questioning, she appeared to have clear insight into her previous respiratory obstruction and strongly protested against any further instrumentation. It was decided to leave a lubricated endotracheal tube in the trachea. Laryngoscopy was difficult and, in spite of cocainization of the pharynx, vomiting occurred several times, necessitating removal by suction. The oral tube was re-introduced and cocainization of the trachea controlled coughing. She obeyed instructions and agreed not to pull out the tube. Examination of the chest at this time revealed normal sounds on the right, but basal dullness with crepitations on the left.

In the ward her condition remained satisfactory for about five hours, after which she was reported to have become unconscious with an impalpable pulse. She died before medical advice could be obtained.

At post-mortem there was found gross and advanced pulmonary oedema involving both lungs for more than two-thirds of their substance. Much fluid was present in the bronchioles, but there was no evidence of bronchopneumonia or atelectasis. The mucosa of the trachea and bronchi was bright red and moist but firmly applied to the cartilaginous wall of which the rings were clearly visible, indeed, the pathologists were inclined to be sceptical about the oedematous and folded character of the mucosa we had seen the evening before! No ulceration was found, but small submucosal haematomata were present on the inner surface of the cricoid just below the

cords. There was some dilatation of the right side of the heart.

This case raises three points of interest, firstly, the character of the coma resulting from respiratory obstruction, secondly, the progressive pulmonary oedema and, thirdly, more important, the nature of the obstructive tracheitis.

The patient showed no evidence of cerebral damage as a result of anoxia and it seems likely that the depth of the coma was due to carbon dioxide retention, particularly as her cyanosis was somewhat, although not completely, relieved by pure oxygen prior to intubation, but without change in the depth of unconsciousness.

The five hours of severe respiratory obstruction resulted in some pulmonary oedema as moist sounds were heard in the left base. Presumably the changes induced in the pulmonary capillaries and endothelium were so severe that the oedema continued to develop after the extreme negative intrapleural pressure had been relieved, and this was the unanticipated cause of the fatality.

The gross inflammation and oedema of the tracheal mucosa extended from the lower border of the cricoid cartilage for 2.5 in. down the trachea. Pressure by a cuff for nearly two hours might have induced an inflammatory response, but it seems probable that an infective process was superimposed as the rest of the trachea and bronchi were inflammed. The patient had received penicillin 100,000 units with streptomycin 0.25 g., six hourly on the day of operation and on subsequent days. The possibility of diphtheria was entertained, but excluded by the bronchoscopic findings. Unfortunately, no swab was taken at the time of bronchoscopy and the nature of the secondary infection remains speculative.

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BOOK REVIEW

Toxaemias of Pregnancy. By John Sophian, M.D., F.R.C.S., M.R.C.P., M.R.C.O.G. Published by Butterworth & Co., London, 1953. Pp. 210. Price £1 5*s*.

This is an excellent monograph on a baffling subject. Mr. Sophian has long held that reflexes set up by heightened tension in the uterus result in a shunt of arterial blood in the kidney away from the cortex to the medulla. Prolonged cortical ischaemia induced by the utero-renal reflex is responsible for the classical signs of hypertension, oedema and albuminuria, and possibly oliguria or anuria. "Anuria represents the complete breakdown of renal function and is to be regarded as a catastrophe of the first magnitude." The mechanism of the increased urinary output following some general anaesthetics, conduction anaesthesia and veratrone are clearly set out. The references are full and general acknowledgement is made to the work of others. It is not clear to the reviewer why the book carries the title it does, since Mr. Sophian in Chapter 8 objects to the "toxaemic" label, and explains "the etymology implies a toxin and modern concept has largely weaned itself away from this notion".

Brit. J. Anaesth. (1954), **26**, 38.

ANNOTATION

ON ANTIDOTES

NOT only the philosophers but the physicians of old were attracted to the idea of opposites. So are we today. Good and evil, heat and cold, fire and water, dryness and moisture, Evipan and coramine, curare and neostigmine—all have held the imagination. So far, only Alice in her Wonderland was entirely satisfied that a nibble of this would counteract with certainty a nibble of that. She, however, was a trusting little girl, and followed implicitly the instructions on her cakes and bottles—"eat me" or "drink me". Anaesthetists on the other hand, over the years, have learnt to be cautious. The supposed antagonism between the barbiturates and the "analeptics", for example, undoubtedly was the indirect cause of many unnecessary deaths, because the importance of artificial respiration and oxygenation was overlooked. The same sort of thing happened in the early days of the relaxants, when neostigmine alone was believed to be the only necessary treatment for overdose. Anaesthetists soon learnt by experience that this was not so, and a general revulsion followed. Indeed, within a short time after the introduction of curare, the general advice turned for a while against the use of neostigmine altogether and stressed artificial respiration for cases of overdose.

The latest newcomer to the field of antidotes is N-allylnormorphine; the somewhat enthusiastic early papers based both on pharmacological and clinical evidence claimed that this close relative of morphine itself, would counteract the respiratory and circulatory depression of morphine overdose. The chief effect of the new drug appeared to be on the respiration, and subjects who had been given an overdose of morphine showed with N-allylnormorphine an increased respiratory rate and minute volume, although sedation was, perhaps surprisingly, little affected. So enthusiastic were the reports that some workers used and advised the administration of N-allylnormorphine to new-born infants suffering from respiratory depression when the mother was believed to be unduly under the influence of morphia at delivery.

N-allylnormorphine was reported to be an antidote only to morphine and its derivatives, and to certain synthetic pharmacologically analgous drugs. It did not show any antagonism to the effects of overdose by barbiturates or general anaesthetics.

The opportunities for the use of such a drug are ordinarily uncommon in anaesthetic practice, but no doubt most anaesthetists on learning of N-allylnormorphine kept an ampoule handy on their theatre shelves. Now, Payne in this issue (p. 22) mars the picture, for in his experiments with N-allylnormorphine he was unable to demonstrate the expected antagonism to morphine. Not only that, but many of the side effects of the drug were unpleasant and prolonged; his patients showed marked drowsiness and a high incidence of nausea and vomiting.

He concludes that N-allylnormorphine is unlikely to be of use in cutting short the after-effects of clinical doses of morphine and dismisses as unlikely any looked for usefulness of N-allylnormorphine in allowing morphine to be given to out-patients and obviating the need for prolonged supervision before going home.

The battle of an antidote is seemingly breaking out once again. No doubt it will be fought strongly, as hitherto, by both sides. Anaesthetists in the side lines should bear in mind, however, when using N-allylnormorphine, that the substance is chemically and pharmacologically a very near relative of morphine, and that, although the antagonistic effect of N-allylnormorphine to respiratory depression of morphine may be in some doubt, certain of the known effects of morphine —notably sedation and vomiting—are likely to be increased. Its use, therefore, for the time being, should be attended by caution and a spirit of inquiry. The number of helpful antidotes on the anaesthetist's list can be counted on the fingers of one hand. It will be an advance to add another, but it seems that more evidence of both the safety and effectiveness of N-allylnormorphine will be needed before the entry can be made with confidence.

Brit. J. Anaesth. (1954), **26**, 40.

THE FIRST CYLINDER OF GAS

BY

M. H. ARMSTRONG DAVISON

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ACCORDING to Duncum (1947), the first suggestion of the compression of medicinal gases into cylinders was made in the *British Medical Journal* on April 11, 1868, and " in the following July nitrous oxide compressed into metal cylinders, although not sufficiently to liquefy the gas, was for the first time produced on a commercial scale by the firm of Barth ".

It therefore seems valuable to record some details from an anonymous publication which has recently come into my hands, and which suggests that the first use of gas compressed into cylinders occurred at least 12 years earlier. The title-page is as follows:

PNEUMA-THERAPEIA;
or the
USE OF PURE OXYGEN
and other gases
shewn to be
easy of application, strictly in accordance
with pathological science, and
particularly efficacious as
medicinal remedies
in various
INTRACTABLE DISEASES,
LONDON:
published at the Medical Pneumatic
Apparatus Company's Offices,
No. 46, Regent Circus, Piccadilly;
and from all booksellers.
1856.

At the bottom of the title-page occurs the pencilled signature, " G. Barth ", which is highly suggestive.

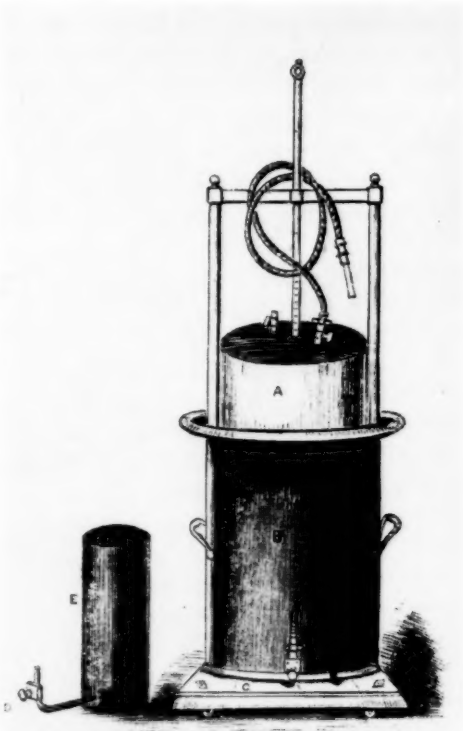

FIG. 1

On the page after the title-page occurs the illustration herewith (fig. 1), the caption reading, " Patent pneumatic inhaling apparatus and bottle of compressed gas ".

The book contains 79 pages, dealing almost exclusively with the use of oxygen. However, on page 73 is a reference to nitrous oxide which is worth quoting:

> The inhalation of the protoxide of nitrogen (laughing gas of Sir Humphry Davy) is well known as a curious and amusing lecture-room experiment. If used diluted with air in properly regulated doses, the customary effect of large doses undiluted is never produced; it has then a most beneficial influence in many deranged functional conditions; rapid cures of defective vision, deafness, and certain forms of paralysis have been accomplished by it. It has also a remarkable effect on the animal spirits, and causes a happy tone of feeling which is not succeeded by depression as is customary after the use of alcoholic stimulants. A single dose is often sufficient to avert an approaching fit of melancholy or hypochondriasis. As it powerfully increases muscular strength it certainly deserves to be tried in cases of lingering and difficult parturition when the expulsive uterine efforts are nearly exhausted.

This last sentence seems almost as prophetic as the celebrated remark by Humphry Davy more than half a century before.

On Page 77, we read:

> Medical practice requires that the gas be obtained in the utmost state of purity, *ready-made*, and that it shall not be absolutely necessary for the patient to go to the gas, but that it be brought to the patient as easily and cheaply as his bottle of ordinary medicine.
>
> Oxygen and other gases required in medical treatment, are too large in bulk to be conveniently transmitted, and even if sent out in their ordinary form are almost certain to escape and be wasted when used. But they are subject to a law of condensation and compression, by suitable mechanical and chemical contrivances. The inventor taking advantage of this law, has succeeded in rendering oxygen and other medicinal gases PORTABLE. Enough gas to serve a patient generally for ten or twelve days, can be supplied in a wrought iron bottle, which has little more than five pints of liquid measure capacity. This bottle is adapted to the inhaling or immersing apparatus, and supplies the proper dose of gas, without any risk of waste, by merely turning a screw. It can be sent by hand, or by carrier, or by railway, as readily as a bottle of brandy, and when emptied is as easily refilled; a patient provided with one apparatus and two bottles may always ensure a supply of gas by returning the empty to be re-charged while he is exhausting the full one.
>
> The medical practitioner can, by this method, obtain his supply of medicinal gas, like any other medicine. The bottle will stand in a corner of his dispensary as safely as a bottle of *liq. amm.* and be as ready for use when required.

The booklet concludes with a remark which suggests that this commercial supply of bottled gases was at least ready to be launched:

> " The Medical Pneumatic Apparatus Company " is ready to execute orders and supply gas. A Prospectus and description of their apparatus, with charges for sale or hire, and all other information, will be forwarded gratis by post, or furnished personally by applying to " *The Manager, Medical Pneumatic Apparatus Company, 46, Regent Circus, Piccadilly, London.*"

Unfortunately, efforts to trace this company have borne no fruit. Perhaps the demand for the commodity was lacking, and it may be that a ripple on the waters of history is the only achievement of this progressive Company.

REFERENCE

Duncum, B. M. (1947). *The Development of Inhalation Anaesthesia*, p. 289. Oxford Univ. Press.

Brit. J. Anaesth. (1954), **26**, 42.

EMINENT ANAESTHETISTS, No. 9

ZEBULON MENNELL

BY

J. F. RYAN

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AN outstanding figure in the British field of anaesthesia during the last fifty years has been Zebulon Mennell, who has only recently retired from active practice after a long and most successful career.

Mennell was born on June 15, 1876, in London, where his father, Zebulon Mennell, was for many years in general practice. His grandfather, also a doctor, practised in Yorkshire, and was a Quaker. His mother was a Scot, the daughter of George Gillies, of Edinburgh, and numbered among her antecedents Lord Gillies, who was historiographer to King George the Third.

Mennell was educated at St. Paul's School. He decided at an early age on a medical career and entered his father's old Medical School at St. Thomas's Hospital in 1895. He qualified M.R.C.S., L.R.C.P. in 1900, proceeding to the M.B. of London University in the following year. He held the resident appointments of House Physician and Senior and Junior Obstetric House Physician at Thomas's, and was also Clinical Assistant in the Ear and Throat Departments. He then worked for a period as Clinical Assistant at the West London Hospital and at the East London Hospital for Children, Shadwell.

In 1902 he started in general practice in the West End of London. He was an able and astute doctor and his practice flourished: he never gave it up, always taking the view that it helped him towards a balanced approach to anaesthesia, which was his main interest, but offered by itself too restricted a field to satisfy him. This combination of two busy practices involved periods of extremely hard work and would be impossible nowadays for one man to sustain. Operating lists take much longer to complete, and the range of the anaesthetist's activities has increased.

As a student and resident Mennell had become greatly interested in anaesthetics. His teachers were two well-known anaesthetists, Walter Tyrrell and Harold Low. When Tyrrell and E. H. G. Morris retired from the Thomas's staff in 1904, Arthur Bevan and Mennell were appointed to succeed them. At the beginning of his career Mennell was fortunate to find himself working with a distinguished surgical staff, which included Makins, Battle, Ballance, Wallace and H. B. Robinson, soon to be joined by Sargent and Nitch. Again, when he was made Anaesthetist to the National Hospital for the Paralysed and Epileptic, Queen Square, he was to be in surgical company of the highest order.

In these years before the first world war, advances in anaesthesia were not on the whole keeping pace with the increasing demands of surgery. This applied parti-

cularly to anaesthetics for operations on the brain and abdomen. When Mennell joined the staff of the National he worked principally with Victor Horsley and Percy Sargent. Horsley was at the height of his powers and the leading brain surgeon of his time. He was completely ambidextrous and his technical skill was phenomenal; he rarely took more than

ZEBULON MENNELL

half an hour over a head case. Sargent was a brilliant and resourceful operator. His time for a similar case was about an hour, and sometimes considerably less. The anaesthetic requirements of these men appeared to be simple; each asked for the lightest possible anaesthesia, Horsley insisting on chloroform and Sargent on ether. But from the anaesthetist's point of view the proposition was far from being a simple one. The anaesthetic had to be given by the oral route, using some sort of mask or face piece. Proper access to the head was prevented by the requirements of surgical technique and the need to preserve asepsis. For Horsley's cases Mennell used the Vernon Harcourt chloroform inhaler, and the difficulties in a case such as a cerebellar decompression, with the patient in the prone position and the head acutely flexed, can be imagined. It was impossible in some cases to provide quiet, uneventful anaesthesia, and there was an obvious need for some new technique. Ether, administered rectally and intravenously, paraldehyde given in a similar manner, and intravenous alcohol were all tried, and for one reason or another were found to be unsatisfactory. For some time there had been favourable reports from Russia and Germany of the use of hedonal as a general anaesthetic. It was given in solution in normal saline by continuous intravenous infusion. The method was introduced into this country by C. M. Page, now Sir Max Page, early in 1912, and he used it extensively at St. Thomas's Hospital during that year. Mennell was impressed, and decided to try hedonal in a series of craniotomies; he used the internal saphenous vein at the ankle for the infusion. In a paper read before the Medical Society of London in 1912, and subsequently published in their *Transactions*, he described the results in 56 cases as "good". In the following year, in a further paper read at the International Congress of Surgery in London, he stated that he considered hedonal to be "by far the safest and most convenient anaesthetic for use in intracranial surgery". Altogether between 1912 and

1914 he gave hedonal in over 200 head cases. Then the war came and the supply from abroad ceased. This proved to be of no consequence, as a most important advance in anaesthesia in this country had already taken place. This was the introduction from America, by Kelly, of Liverpool, of the technique of intratracheal insufflation of ether. Mennell was one of the first to use this procedure in London, and became one of its leading exponents. He saw that it offered a great step forward in anaesthesia for cerebral surgery performed by the rapid method. This form of anaesthesia was so successful that he continued to use it in many hundreds of cases for fifteen years after the war, and it was only when a slower operating technique was adopted by Sargent's successors that he abandoned it in favour of endotracheal inhalation, using nitrous oxide and oxygen, with minimal reinforcement by ether or chloroform. Mennell was highly skilled in the use of the laryngoscope, realizing that the secret of intubation of the trachea under direct vision was to have the patient well under the anaesthetic with good muscular relaxation. This was a fact that many anaesthetists failed to appreciate in the early days of intratracheal work, and as a result there were numerous abortive attempts at intubation and much turbulent anaesthesia.

Mennell always insisted that a completely unobstructed airway was essential in order to obtain good abdominal relaxation. The introduction in 1908 of the artificial pharyngeal airway, generally attributed to Hewitt, was a most notable step forward, as the most discriminating anaesthetists at once recognized. Strangely enough, this simple but great aid to good anaesthesia was not generally adopted for several years, a number of anaesthetists preferring to carry on with tongue clips and kindred instruments, as often as not with some degree of respiratory obstruction. In spite of a general improvement, Mennell was still not satisfied with the standard of relaxation of the abdomen which was being obtained by the prevailing methods of inhalation anaesthesia. The surgeons needed better conditions in which to carry out the much more considerable procedures which were becoming normal practice in abdominal surgery: complete relaxation was required for a longer period. Chloroform was obviously not the anaesthetic of choice, and current teaching was full of warnings of the risk of respiratory failure and death if a really deep level of ether anaesthesia was reached. The late Felix Rood, Anaesthetist to University College Hospital, did not hold this view about ether. Mennell was of the same opinion, and, at Rood's suggestion, decided to put deep ether anaesthesia to the test. This he did in a long series of abdominal cases at Thomas's. Rood carried out a similar investigation. They came to the conclusion that, in healthy patients, this was a safe way of providing the sort of relaxation that the surgeons had been hoping for, more profound than had previously been secured by inhalation methods, and comparable in degree to that obtained by spinal block, or, at the present day, with the curarizing agents. Mennell early made the observation that perfect abdominal relaxation occurred when there was complete paralysis of the vocal cords: it was then that there was an absolutely free air-

way. This method had its detractors. But an important point must be borne in mind ; it was unusual for any abdominal operation to take much more than an hour. Surgeons realized that in the prevailing conditions speed was a matter of importance, and their technique was equal to this demand. Mennell was always the first to agree that unduly prolonged deep ether anaesthesia was to be avoided. With this limiting factor of time, this method was taught by Mennell and his disciples at Thomas's to a long succession of students and young residents. It is, perhaps, sufficient to say that, during the years between the two wars, there was always a demand from provincial hospitals for young Thomas's men to fill house appointments which carried with them anaesthetic duties.

Mennell will be remembered first and foremost as a very fine practical anaesthetist, completely equipped technically, but above all a master with both ether and chloroform. During the years when most of his work was done there were none of the short cuts to good anaesthesia which so considerably ease the task of the anaesthetist of today. In maintaining a consistently high standard, he was greatly helped by possessing an ideal temperament. He was confident and serene, and handled his anaesthetics firmly and positively. He never looked for trouble, but if any emergency did arise was completely unruffled and in command of the situation. He got his results by the simplest possible methods and with an entire absence of fuss. He was not interested in gadgets, and any modifications to apparatus were made for the sake of safety and simplicity. Thus he introduced the Mennell Bottle, an improved version of the Junker inhaler, for use in obtaining obstetric analgesia. He designed this in such a way that full anaesthesia is unobtainable, it cannot be upset, and wrong connections and overfilling are impossible.

His favourite method of inducing anaesthesia in an adult was with a nitrous oxide ether sequence, using the Clover's inhaler. He was always devoted to the Clover, and sometimes used it throughout an operation, taking suitable steps to avoid an undue accumulation of carbon dioxide. His average time in the anaesthetic room was about three minutes, and there was never any delay between cases.

Although as an anaesthetist Mennell was always completely composed, he could on occasion be a formidable figure in the theatre. One thing above all that he could not abide was what he called " slow motion " surgery, delay in getting on with the job. As there were no resuscitation methods as we understand them nowadays, no antibiotics, and a time limit beyond which it was unwise to prolong the anaesthetic, he was undoubtedly right. One cannot help wondering how he would have stood up to the prolonged procedures which are occupying an increasing proportion of operating time today. Two essential qualities in the modern anaesthetist are stamina and patience. Mennell has been blessed with a good constitution, but perhaps it is well for his peace of mind that his period of greatest activity occurred when it did. A measure of his skill is provided by the success he enjoyed in his private anaesthetic practice. His services were in great demand, not only by his colleagues at his two hospitals, but also by many other surgeons, especially

when a guarantee of real abdominal relaxation was required.

He was an excellent teacher, who believed in giving the student the maximum amount of practical work in the operating theatres. He aimed at giving him early confidence, always stressing the fact that the average anaesthetic is essentially a straightforward procedure, depending for its success on the maintaining of an optimum airway at all times; much of his instruction was devoted to this end. Many a Thomas's man has had reason to be grateful for the teaching he received at his hands.

In looking back on his career, Mennell must have the happiest memories of his long association with Sargent, whose anaesthetist he was in both hospital and private practice for nearly thirty years. Sargent was one of the leading neurosurgeons of his day, and often large numbers of spectators, including many visitors from abroad, would come to see him operate. He and Mennell were at their best on such occasions. They worked admirably together, demonstrating with great skill and with a certain panache which will be well remembered by those who saw them. Sargent's untimely death in 1933 was a heavy blow and broke up a fine partnership.

Mennell, with his unrivalled experience, was recognized as an authority on anaesthesia in cerebral surgery, not only in this country but also abroad, and in 1924, at the invitation of Dr. McMechan, he visited the United States and delivered a lecture on this subject in Chicago. This was subsequently published in the *American Journal of Surgery*. His work in this sphere was perhaps his main contribution towards advance in anaesthesia, and was certainly of the highest value in the development of cerebral surgery.

Mennell gave valuable service in both world wars. In the first war, he received a temporary commission as Captain in the R.A.M.C., and was attached to the 5th London General Hospital. Here, in addition to anaesthetic duties, he had charge of surgical beds, and himself undertook heavy operating work, at which he proved to be very skilled. This included, appropriately enough, a number of cranial operations. On many occasions he showed his versatility by acting both as anaesthetist and surgeon. He would pass an intratracheal catheter, connect up to the Kelly machine, and then wash up and perform the operation.

Mennell reached the retiring age at Thomas's in 1936 and was appointed Consulting Anaesthetist after thirty-two years of great service to the Hospital and Medical School. For fifteen years he had been Senior Anaesthetist. During the last war he returned and gave much help, first of all in London and later in the wartime hospital at Hydestile. He remained at the National until 1945, when he retired after being thirty-four years on the staff. The high value of his services was recognized, and he received the signal distinction of being appointed the first, and so far the only, Consulting Anaesthetist to this hospital.

Mennell, a capable lecturer and speaker, has made many important contributions to scientific discussions at the Royal Society of Medicine and elsewhere. In 1935 he visited Australia, attending the annual meeting of the British Medical

Association in Melbourne as a Vice-President of the Section of Anaesthetics. During his visit to this city he delivered the Embley Memorial Lecture at the University. This took the form of a critical survey of the state and trends of anaesthesia at that time, and was a conspicuous success. He has made numerous communications to medical journals and encyclopaedias, both here and in the United States and Australia. He was a member of the old Society of Anaesthetists, which became merged in the Section of Anaesthetics of the Royal Society of Medicine in 1908; he was President of this Section in 1926, and President of the Section of Anaesthetics at the annual meeting of the British Medical Association at Cambridge in 1948. He took a prominent part in the formation of the Association of Anaesthetists, and was its President from 1938 to 1940. He was also the first Treasurer of the Association, guiding its finances with such success that he remained in office altogether for twelve years. He was Chairman of the Anaesthetists' Group Committee of the British Medical Association, from its inception in 1947 until 1952. To all these offices he has brought distinction, great ability in committee and a wealth of experience as a man of affairs. The Association recognized his outstanding work for anaesthesia by awarding him the Snow medal in 1948. Among other distinctions, he holds the Honorary Fellowships of the Association of Anaesthetists of the United States and Canada, and of the Association of Anaesthetists of Australia.

For many years Mennell has been a familiar figure in gatherings of anaesthetists both here and abroad. They hold him in high regard, and wish him well in his retirement in Sussex.

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NEW INVENTIONS

A NEW "TRILENE" VAPORIZER FOR DENTAL ANAESTHESIA

BY

W. J. FINNIE

Bradford Group Hospitals

CONSERVATISM has returned to dental practice. The get-rich-quick harvest from multiple extractions and replacement dentures has been reaped. With reluctance the dental surgeon views the patient whose mouth dictates extraction of teeth.

Nevertheless, it must be faced that there will always be a need for general anaesthesia for dental extractions.

I consider that nitrous oxide and oxygen, with trichlorethylene is the most generally useful choice of anaesthetic for dental extractions. My dissatisfaction with existing trichlorethylene vaporizers has prompted me to take a special interest in this problem and a "Trilene" vaporizer has been made for me which I believe has considerable merit.

Nitrous oxide, either alone or with oxygen, holds a false reputation as the anaesthetic of choice for dental extractions since Macintosh and Bannister (1943) have pointed out that, although statistics may quote a death rate of one in 50,000 administrations of nitrous oxide, they do not show how often an operation has had to be abandoned because of difficulties in maintaining the anaesthesia. Further, Clement (1951) has said that "the production of true or surgical anaesthesia with N_2O necessitates a restriction of the oxygen intake". This is contrary to all the basic principles of anaesthesia, where emphasis is rightly made on adequate oxygenation at all times.

A higher content of oxygen in the nitrous oxide and oxygen mixture is possible using trichlorethylene vapour as supplement to attain the desired level of anaesthesia. The freedom from the insidious effects of anoxia, using this technique, represents an advantage over nitrous oxide alone. This technique can be used with confidence in patients with cardiac or pulmonary disease since the additional oxygen content available benefits the heart musculature. The recovery is admittedly delayed when compared with the recovery after nitrous oxide alone, but the patient is in complete possession of all his mental faculties within five minutes; there is no feeling of nausea or vomiting and the patient can vacate the dental surgery to return home soon afterwards leaving the dental surgeon and anaesthetist with an easy mind.

The "Trilene" vaporizers in use at the present time are usually of the fluid reservoir type, incorporating a wick or baffle plate to increase the surface area of trichlorethylene available for vaporization by a flow of gases. In some models the flow of gases can be made to "bubble" through the liquid trichlorethylene and

this turbulence may even deposit liquid trichlorethylene along the lumen of the delivery tube.

It seems that existing "Trilene" vaporizers of this type were originally designed for use with ether, where the vaporization requirements are quite different. A larger volume of ether requires to be vaporized than of trichlorethylene to reach an equivalent level of anaesthesia.

Most "Trilene" vaporizers incorporate a glass bottle which has a containing capacity of from 50 ml. up to 110 ml. The breakage rate over a period of years, in both hospital and private dental practice, is appreciable. The cementing between the glass and metal or plastic components of these "Trilene" vaporizers also requires frequent attention.

I have found that 6 ml. of trichlorethylene is sufficient to cope with a resistant case, and thus a "Trilene" vaporizer charged with this comparatively small amount should prove efficient. Ostlere (1953) also states that the normal requirement for trichlorethylene is one drachm per hour.

Trichlorethylene is stable when stored in closed containers protected from light, but to avoid possible oxidation it is recommended that a fresh supply be placed in the container every few days. It is obviously bad practice to leave trichlorethylene standing in a clear, glass bottle vaporizer for more than a few days and it is obviously expensive practice to charge a vaporizer with, say 50 or 60 ml. trichlorethylene, and pour it away at the end of each day.

In my opinion the present "Trilene" vaporizers for use with gas flows are either capable of producing a sufficiently strong concentration of trichlorethylene vapour, but do not reach this concentration by a smooth gradual increase in concentration, or they produce a smooth and gradual increase in concentration, but are often not capable of producing a strong enough concentration of trichlorethylene vapour for the case in hand.

From these considerations it is obvious that trichlorethylene requires a vaporizer specifically designed to suit its own properties.

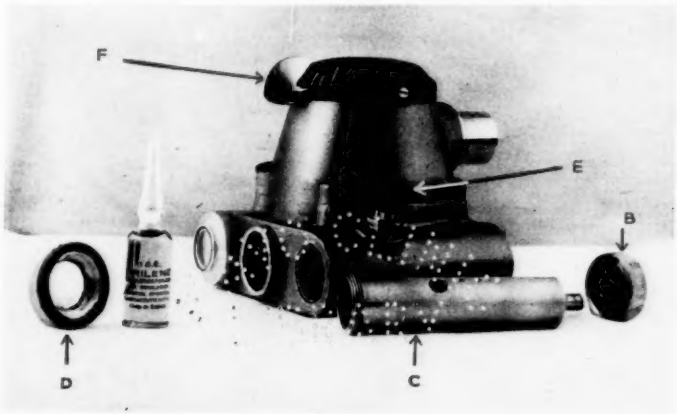

FIG. 1

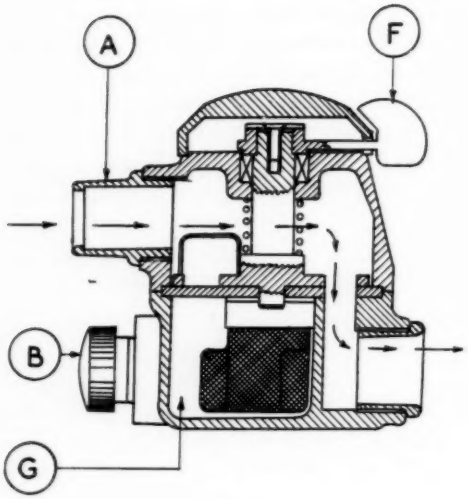

FIG. 2

It will be seen from figures 1 and 2 that the "Trilene" vaporizer here described is of robust construction. The body is made of cast aluminium and incorporates two tubes, each to contain one 6-ml. ampoule of trichlorethylene (fig. 1C). It will be noted there is no glass bottle container. The vaporizer is attached to the gas-oxygen machine by plugging tapered fitting (fig. 2A) into the outlet (fig. 3).

With the vaporizer control at "OFF", gas passes directly through the vaporizer as shown by the arrows (fig. 2). With the control lever F (figs. 1 and 2) in the "MAX." position all the gases will pass through the vaporizing chamber (fig. 2G). In any intermediate position the gases are proportionately diverted. To ensure that this is gradual, the ports have been very carefully arranged. Leakage of gas from the vaporizer through the operating spindle is prevented by a suitable sealing gland.

To charge the vaporizer, one 6-ml. ampoule of trichlorethylene is inserted into each of the tubes (fig. 1C) where they remain unbroken until required. In this

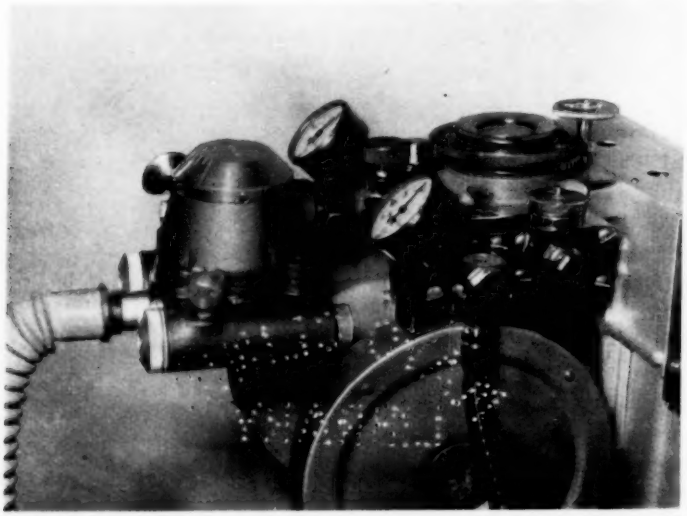

FIG. 3

way the trichlorethylene is retained in its original closed container and protected from light and the risk of oxidation. This allows the vaporizer to stand fully charged ready for immediate use with no possibility of deterioration of the trichlorethylene.

It will also be appreciated that, for anaesthetists visiting several different dental surgeries, the space occupied in carrying ampoules is considerably less than that of a stock bottle of trichlorethylene.

The simple operation of screwing down knob (fig. 1E) will fracture the ampoule and the liquid trichlorethylene will run into the vaporizer chamber (fig. 2G) through matching holes in the tube (fig. 1C) and tube tunnel in the body of the vaporizer. The broken pieces of glass are retained in the tube.

To charge the vaporizer the ampoules are inserted as follows (the letters apply to figures 1 and 2):

(1) Unscrew knob (B) fully and pull cover (D), removing tube (C) from its housing. It may be necessary to unscrew knob (E) slightly to allow full withdrawal.

(2) Unscrew cover (D) from tube (C), insert one 6-ml. ampoule of trichlorethylene and replace cover (D).

(3) Replace this assembly into its housing tunnel, ensuring that the tube engages with the locating pin inside.

(4) Replace knob (B).

The window in cover (D) allows the contents to be checked at any time.

To operate the vaporizer, the fully charged vaporizer is connected to the outlet of the gas-oxygen machine. The chosen mixture of nitrous oxide and oxygen is presented to the patient who is asked to breathe quietly through the nosepiece presented to his nose. It is necessary to ensure that the control lever (F) is at "OFF" and then cap (E) is screwed down until the ampoule is broken. The control lever (F) is now gradually moved across the scale until the trichlorethylene, which is now being added to the gas-oxygen mixture, has the desired effect.

I find that with the lever (F) at the $\frac{1}{2}$ mark, the majority of patients can be kept at a satisfactory level of anaesthesia, with jaws relaxed, for the duration of the dental extractions. The resistant patients I have met have been controlled with the lever (F) advanced to the $\frac{3}{4}$ mark. There is thus a reserve of trichlorethylene concentration available should future patients prove more resistant.

While I have found that 6 ml. of trichlorethylene has proved more than ample for each case, there is always the ampoule in reserve to deal with an extreme demand.

At the end of each case in which I have used an ampoule of trichlorethylene I

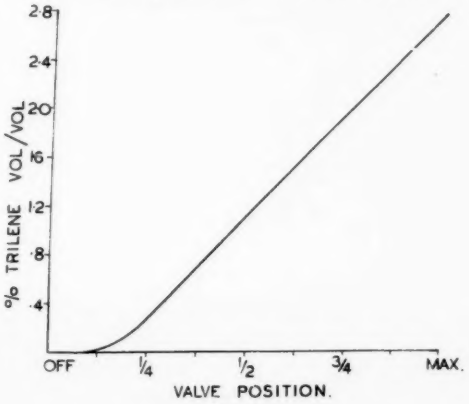

FIG. 4

always make a point of replacing it with a fresh ampoule at my earliest convenience.

In order to illustrate the effectiveness of this vaporizer a series of laboratory tests were carried out, using a sine pump and refractometer, at a tidal volume of 500 ml. and 16 respirations per minute.

Figure 4 shows the result of the increase in the percentage of trichlorethylene added to the gas supply as the lever is moved across the scale from "OFF" to "MAX.". It shows the smoothness of the addition of trichlorethylene very clearly. There is no sudden rise in trichlorethylene concentration, for it is only by this smooth addition of trichlorethylene that coughing can be prevented.

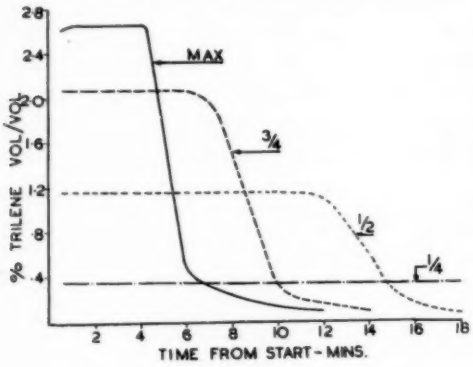

FIG. 5

Figure 5 shows the strength and duration of the trichlorethylene vapour supplement when using one ampoule (6 ml.).

The restriction to breathing was tested by measuring the volume of air passing through the vaporizer with the control lever set at the different positions with a constant input pressure of 0.5 in. water. The results were as follows:

Valve setting	Flow in litres per min. at 0.5 in. water
OFF	60.5
¼	59.5
½	58.7
¾	56.4
MAX.	53.2

From the above results it is apparent that the restriction to breathing is extremely low and consistent over the range of valve settings.

My thanks are due to Messrs. Cyprane Limited, Keighley, for making this vaporizer.

REFERENCES

Macintosh, R. R., and Bannister, F. B. (1943). *Essentials of General Anaesthesia*, Oxford: Blackwell.

Clement, F. W. (1951). *Nitrous oxide-oxygen Anaesthesia*, London: Kimpton.

Ostlere, G. (1953). *Trichlorethylene Anaesthesia*, Edinburgh: Livingstone.

Brit. J. Anaesth. (1954), **26**, 53.

THE DIRECT THROAT SPRAY

BY

A. OWEN-FLOOD

Hornsey Central Hospital

SOME years ago I modified a Macintosh laryngoscope by building in a spray device for visible topical analgesia of the larynx. (Owen-Flood, 1948.) I have now perfected a handier instrument without altering the laryngoscope itself. The spray (fig. 1) attachable to the laryngoscope is

FIG. 1

easily adaptable to any other type, curved or straight blade. As illustrated the bottle, screwing into the head, is of 6 cc. capacity and marked off in ccs. The air tube attached to the blower has a small perforation and thumb depression for regulation of flow, and allowing without undue syphonage the spray to be used upside down should the normal sitting up position be impossible.

The clamp is fastened around the laryngoscope and the bottle can be conveniently clipped on and as easily removed for filling and cleansing. By using the spray a full view is gained and the agent applied just where it is needed. It is possible to direct the spray right between the vocal cords into the trachea.

Various grades of spray nozzles and spray tubes to fit any type of blade can be supplied by the makers, Messrs. Down Bros. & Mayer Phelps Ltd.

I am indebted to Messrs. Down Bros. for making the instrument for me, and for much valuable advice.

REFERENCE

Owen-Flood, A. (1948). *Brit. med. J.*, **1**, 114.

CORRESPONDENCE

Cardiac Effects of Hypotension

Sir,—I feel that at the present time many anaesthetists in this country must be exercised in their minds as to the advisability of employing "controlled" hypotensive techniques, in view of the increasing evidence that the dangers of such practise are more than theoretical. It is of the greatest possible importance than any article purporting to deal with this problem should be well-conceived and authoritative, and not under any circumstances likely to mislead practical anaesthetists whose knowledge of other specialities is limited.

Swerdlow and Wade have recently published an article (*Brit. J. Anaesth.*, **25,** 284) in which they claim to have demonstrated in a small series of cases that anti-Trendelenburg tilting and the exhibition of hexamethonium iodide produced no electro-cardiographic evidence of structural myocardial change. Since their observations extended only until the blood pressure had ceased to fall rapidly, and were confined to alterations in the P wave and P-R interval, it is not surprising that evidence of structural change was not forthcoming. In any case it is the oxygen supply and functional capacity of the myocardium which are important, and in fact figure 2, which illustrates their article, shows inverted T waves and slight S-T segment depression, on which no comment is made. These changes may or may not be significant, and I feel that it would have been interesting to see a full set of chest leads from this case, extending throughout the hypotensive period.

JAMES PARKHOUSE
(R.A.F., Lincoln)

Percentages of Nitrous Oxide

Sir,—Dr. Preston's valuable review (*Brit. J. Anaesth.*, October 1953) of anaesthesia for mitral valvotomy was marred in one respect. He referred more than once to "a 50 per cent $N_2O : O_2$ mixture". In its context the author clearly implies that this is a mixture inhaled by the patient, whereas it probably means the mixture delivered from the flow meters. The composition of the gas mixture entering a carbon dioxide absorption system bears but an indirect relationship to the composition of the gases inspired by the patient. Foldes (1952) in particular deals with this subject at length. The composition of the inhaled gases depends among other things on the oxygen consumption and therefore indirectly on the weight of the patient, and also on the total gas flow from the meters. Dr. Preston's somewhat loose statement, if taken at its face value, might lead colleagues to set their flow meters to deliver a 50 per cent $N_2O : O_2$ mixture in the belief that their patients were inhaling such a mixture. In fact the latter may receive far less oxygen than is imagined, particularly when large subjects are being anaesthetized and when small total gas volumes are delivered into the absorption system.

WILLIAM W. MUSHIN
(Cardiff)

REFERENCE

Foldes, F. F., Ceravolo, A. J., and Carpenter, S. L. (1952). *Ann. Surg.*, **136**, 978.

BOOK REVIEW

Inhalation Therapy and Resuscitation. By Meyer Saklad. Published by Blackwell Scientific Publications. Pp. 338; illustrations 130. Price £2 14*s.* net.

Let it be said at once that this is an excellent book. The author earns our thanks and congratulations for a comprehensive survey of the many methods presently available for inhalation therapy and resuscitation. He has collected into a single book the great mass of information which has appeared in individual articles, a fact evidenced by a bibliography containing four hundred and two references. It is pleasant to find the term of anoxia discarded for the more accurate and preferable hypoxia, a new and working classification of which proves an attractive feature of the monograph. This arrangement is most satisfactory in its clarification of the value and effect of oxygen therapy in each instance, and prepares the reader for the valuable chapter on the pathological effects of hypoxia. The symptomatology of hypoxia is presented in some detail so that early recognition of the condition will result in the prompt institution of suitable therapy.

This volume appears opportunely for anaesthetists who are increasingly involved in problems of respiration and ventilation of the lungs in surgery, in medicine, in industrial accidents and in the treatment of poliomyelitis with accompanying bulbar paralysis. The various methods of treatment and the problems of resuscitation are clearly expounded, and the necessary equipment is explained and evaluated, but no account of some of the more recent types of spiropulsator has been included. Such an omission is paralleled by the statement that the problem of maintaining ventilation in forms of poliomyelitis where there is bulbar or pharyngeal paralysis, is *by no means near solution.* Experience in a recent epidemic has shown that a solution is at hand. The author's suggestion that in patients who "fight" a respirator, curarization might be a solution has proved correct in practice.

In so satisfying and well-illustrated a book as this, one hesitates to suggest that a diagram would help to clarify the early section on the neural control of the respiration. There is considerable interest also in the statement on the possibility that vulnerability of the liver to hypoxia seems to be due to its primary dependence on the venous blood of the portal vein to supply its oxygen—40 per cent of the liver supply comes via the hepatic artery.

This well-written monograph is pleasantly easy to read and handsomely produced with the usual full index. It is a valuable addition to the familiar American Lecture Series and should occupy a place in the library of those interested in this growing form of therapy.

FACULTY NEWS

HONORARY FELLOWSHIP OF THE FACULTY

Sir Gordon Gordon-Taylor, K.B.E., C.B., has been elected to the Honorary Fellowship of the Faculty in appreciation of his exceptional work in the field of medicine and anaesthesia in particular.

THE MITCHINER MEDAL

The Royal College of Surgeons is proposing to institute a Mitchiner Medal in memory of Mr. Philip Mitchiner, C.B., C.B.E., T.D. This will be given each year to the most outstanding officer in the Royal Army Medical Corps. Members of the Board of Faculty have been privileged to contribute to this Medal.

ELECTIONS TO THE FELLOWSHIP OF THE FACULTY

The following have been elected to the Fellowship of the Faculty:

Anderson, S. M.
Angel, R. E.
Armstrong, D. M.
Aserman, D.
Atwood, J. H.
Auld, W.
Bacon, W. B.
Ballantine, R. I. W.
Bannatyne, B. N. P.
Barnes, H.
Barnes, M.
Barnsley, A.
Barry C. T.
Bashall, C. J.
Bateman, D. V.
Baxter, V. T.
Beddard, J. R. J.
Belam, O. H.
Bellman, G.
Bereen, J. F.
Bingham, W.
Binning, R. A.
Bird, H. M.
Blackburn, G. H.
Blackston, P. H.
Blazeby, R. H.
Bodman, R. I.
Bolster, J. A.
Borland, C.
Bowen, R. A.
Bramwell, S. D.
Brinkworth, D. J. T.
Bristow, T. R. M.
Brittain, G. J. O.
Bromage, P. R.
Brown, A. S.
Brown, D. M.
Brown, R. C.
Brown, V. M.
Brown, W. M.
Bryce-Smith, R.
Bryn-Thomas, K.
Buckley, J. C.
Bulcock, C. H.
Burns, T. H. S.
Burrows, J. D.
Buxton, J. D.
Campbell, G. W.
Campbell, U. M.
Carden, S.
Carnegie, D. M.
Carter, D. J.
Chadwick, T. H.
Challenger, J. H.
Cheatle, C. A.
Chippindale, F. W.
Christie, A.
Clutton-Brock, J.
Clynick, F. E.
Coden, B.
Coles, P. F. de C.
Cooper, J.
Cope, D. H. P.
Copp, T. A.
Cranmer, J. G.
Crawford, A. S.
Crawford, J. H.
Crawford, K. S.
Dale, H. W. L.
Davies, D. J.
Davies, R. M.
Deane, W. W.
De Clive Low, S. G.
Dinnick, O. P.
Dinsdale, T.
Dinwoodie, W.
Dodd, H. G.
Dorman, J. K. A.
Doughty, A. G.
Dundee, J. W.
Dunn, C. H.
Eason, G. A.
Easson, J. C.
Eastwood, A. B.
Ebsworth, J. D.
Edwards, H.
Elliott, J.
Ellis, G.
Enderby, G. E. H.
English, I. C. W.
Esplen, J. R.
Etheridge, F. G.
Evans, W. E. F.
Faragher, E. C.
Faulkner, F.
Fenton, E. S. N.
Finnie, W. J.
Fisher, R. A.
Fox, G. P.
Fraser, A. C.
Galbraith, M. L. A.
Gallie, J. R.
Gardner, E. K.
Gavin, P. R.
Gibbs, F. G.
Gilchrist, E.
Gilmore, W. R.
Glazer, P.
Gleadow, E. F.
Goldsmith, M. W.
Goodhart, C. E. D.
Grabossky-Atherstone, R. N.
Graham, J. M.
Granat, A. H.
Green, M. W. S.
Grieve, R. G. R.
Griffin, J. L.
Griffiths, H. F.
Griffiths, J. A.
Grigor, K. C.
Grindlay, R. W. G.
Gunaratne, C. M. H.
Hall, J. L.
Hargadon, J. J.
Hargreaves, J. B.
Harris, R. L. H.

Harrison, G.
Hawkins, G. F.
Hawksley, Margaret
Hawthorne, A. T.
Hayes, C.
Headley, S. R. T.
Hegarty, A. B.
Helliwell, P. J.
Hewer, A. J. H.
Hewett, J. C.
Hill, H. C.
Hill, J. A.
Hind, A. W.
Hobbes, T. H.
Holmes, F.
Hopkins, J. L.
Horton, J. A. G.
Howat, D. D. C.
Howell, J.
Howell-Hughes, T.
Hudson, E. G.
Hughes, G.
Hunter, A. R.
Hutton, A. M.
Issaccson, E.
Ives, J.
James, C. D. T.
James, L.
Johnson, B. D. L.
Johnson, E. E.
Johnston, J.
Johnstone, M. W.
Jones, D. S.
Jones, I. R.
Jones, W. M.
Kennedy, A. O. D.
Kenny, Sheila
Knight, D. A.
Knowles, G. S. A.
Lake, R. H. N.
Lattey, R. A.
Lawrence, R. C.
Lawrie, R.
Laycock, J. D.
Leng, J. E.
Lewis, I.
Lewis, Mrs. Ivor
Lloyd-Owen, M. W.
Love, S. H. S.
Lucas, B. G. B.
McClelland, F.
McCully, I. M.
McGuirk, B. H.
Mackenzie, A.
Mackintosh, F. G.
McLoughlin, G.
McNeil, J. S. B.
Maidlow, W.
Marrett, H. R.
Marson, E. A.
Mason, S. A.
Merry, R. S. M.
Millar, A. Mc.
Miller, A. G.
Milne, E. H.
Milne, R. P.
Montgomerie, J.
Monypenny, I.
Moore, R. H.
Morrison, L. G.
Murray, T. P.
Odell, J. R.
O'Donoghue, D. M.
O'Down, J. R.
O'Hara-Proud, F. R. P.
Orr, C. J. K.
Overton, P. M.
Panton, G. F.
Patterson, W. J.
Picken, D. K. W.
Pooler, H. E.
Porter, N. C.
Powell, K. J.
Priestley, Norah, K.
Quayle, G.
Rae, W. K.
Rankin, A. C. R.
Rawlins, G. A.
Rea, G. H.
Reckless, D.
Redgate, J. W.
Reid, C.
Rendell-Baker, L.
Reynaud, A. L.
Rice, R. A. C.
Rickards, J. F.
Ritchie, B. W. T.
Roberts, B. C.
Roberts, H.
Roberts, T. B. L.
Robertson, A. I. G.
Robertson, J. D.
Robson, J. G.
Rochford, J. D.
Rollason, W. N.
Rook, J. R.
Ross, K. M.
Sanders, D. M.
Sandiford, H. B. C.
Saunders, R. C. O.
Scobie, J. D.
Scurr, C. F.
Sellick, B. A.
Shackleton, R. P. W.
Shafto, C. E.
Shaw, M.
Shippard, S. G.
Sinclair, A. D.
Sinclair, R. N.
Smith, A. J.
Smith, Mrs. D. A.
Smith, D. I. H.
Smith, J. A.
Spacek, M. R. W.
Spence-Sales, D.
Steel, G. C.
Stephens, K. F.
Stocker, T. T.
Stocquart, E.
Straton, J.
Stride, S. D. K.
Sullivan, B.
Sunderland, A.
Swerdlow, M.
Sykes, R. G.
Tate, E. I.
Taylor, J. H.
Theron, L. L.
Thomas, J. P.
Thornton, H. L.
Tindal, A.
Tom, A.
Townsend, C. G.
Turner, F. L.
Turner, J. T.
Vourc'h, G.
Walls, N. S.
Warnock, J. G.
Ward, A. B.
Ward, A. E.
Ward, A. J.
Waters, H. S.
Watson, K. M.
Way, G. L.
Wheeler, H. Q. O.
Wheldon, J. T.
Whiting, R. J.
Williams, R. E.
Williams, S. T. M.
Willis, J. H.
Wilson, D. S.
Wilson, H. L. J.
Wilton, T. N. P.
Wishart, H. Y.
Wolfson, J. L.
Wood-Smith, F. G.
Woodward, J. W.
Wright, R. B.
Wylie, W. D.
Wyman, J. B.
Wynne, R. L.
Wynter, T. M.
Young, D. S.
Young, H. B.
Youngman, H. R.
Zuck, D.

SCIENTIFIC MEETING

A Scientific Meeting was held on Saturday, November 21, 1953 at the College, which received a capacity attendance of 350. So great was the response to this Meeting that many were unfortunately unable to obtain tickets.

The following was the programme:

10 a.m. "Venous and Pulmonary Reflexes and the Circulation", by Professor David Whitteridge, B.Sc., D.M. (Professor of Physiology at the University of Edinburgh).

11.30 am. "Reflex Circulatory changes in Normal and Anaesthetized Man", by Professor E. P. Sharpey-Shafer, F.R.C.P. (Professor of Medicine at St. Thomas's Hospital, London).

2.15 p.m. "Cardiac Output in Certain Disorders of Circulation", by Professor J. McMichael, F.R.S.(Ed.), M.D.(Ed.), F.R.C.P. (Professor of Medicine, British Postgraduate Medical School, Hammersmith).

3.45 p.m. "Extracorporeal Circulation", by Dr. D. G. Melrose, B.M., B.Ch. (Department of Surgery, British Postgraduate Medical School, Hammersmith).

4.45 p.m. Film.

BOARD OF FACULTY ELECTION 1954

An election of three Fellows and one Member of the Faculty to the Board will take place at the College on Wednesday, March 10, 1954, at 3.30 p.m., in the vacancies occasioned by the retirement in rotation of Dr. J. H. T. Challis, Dr. A. H. Musgrove and Dr. George Edwards, representing the Fellows, and Dr. S. A. Mason, representing the Members of the Faculty. Dr. George Edwards is not standing for re-election; Dr. J. H. T. Challis, Dr. A. H. Musgrove and Dr. S. A. Mason are eligible for re-election. The following shall be eligible for election to the Board on complying with the conditions of the Regulations:

(*a*) All Fellows of the Faculty of Anaesthetists, for the three vacancies for Fellows on the Board.

(*b*) All Members of the Faculty of Anaesthetists, for the one vacancy for a Member of the Board.

January 1 was the last date on which nominations for candidates to the Board were received.

PROGRAMME FOR WEDNESDAY, MARCH 17, 1954

4 p.m. Annual General Meeting of the Faculty at the College.

4.30 p.m. Tea.

5 p.m. Joseph Clover Lecture by Dr. T. Cecil Gray.

7.15 for 7.45 p.m. Anniversary Dinner.

POSTGRADUATE COURSES

The following Courses will be held at the Royal College of Surgeons:

Anaesthetics Course.—March 25 to April 14, 1954.

Pharmacology Course.—May 3 to May 14, 1954.

Those wishing to apply for entry to these Courses, particularly those seeking admission to the Tutorials and Clinical Conferences in the Anaesthetics Course, are asked to apply early, as the number of applicants has in the past been greater than it was found possible to accommodate.

In conjunction with the British Council, the Faculty is again arranging a short Course in Anaesthetics for European students. This will take place from March 15 to March 26, 1954, and fifteen students will be admitted.

Educational Supplement

January 1954

REVIEW ARTICLE

FLUID AND ELECTROLYTE METABOLISM: THE PRESENT POSITION

BY

IAN W. MACPHEE

Department of Surgery, University of Liverpool

THE importance of adequate fluid and electrolyte therapy is now readily appreciated, and the principles underlying the correction of deficiencies are well established. Everywhere the importance of base conservation by the body is accepted, and measures taken to correct any deficiency of base substance are rigorously applied. We appreciate clearly the difference between a true water deficiency as emphasized by Marriott (1947) and by Darrow and Pratt (1950), and the more serious "hypotonic" dehydration, where electrolyte is lost in amounts at least equivalent to the water loss. Before operation, we realize that the urinary chloride excretion is a more sensitive index of the body chloride state than is the plasma chloride concentration, and we are accustomed to correcting the fluid and electrolyte imbalance before the patient undergoes the additional hazard of the operation itself. The rapid estimation of sodium and potassium by the flame photometer allows us to control therapy from hour to hour and the lag between clinical and biochemical assessment of the patient's condition now scarcely exists. It is important, however, that the routine of replacement therapy should not blind us to the advances which are taking place in this field.

ELECTROLYTE CHANGES RESULTING FROM INJURY

These advances are mainly concerned with the intimate effects of operation upon fluid and electrolyte metabolism, and it should be clearly appreciated that they are not necessarily related to pre-existent deficiencies. Indeed, the changes to be described occur also in normal well-nourished adults who are not suffering from any water or electrolyte imbalance. The earliest accurate studies of the effects of injury on fluid and electrolyte metabolism were carried out by Cuthbertson and his colleagues (1939) on rats subjected to fracture of the femur. As a result of the injury they observed an increased excretion of nitrogen, phosphorus, sulphur and potassium in the urine. Subsequent

studies have shown that a complex series of changes occur which appear to be the result of injury or operation itself. Howard and Carey (1949) noted a post-operative retention of sodium and chloride in amounts greater than theoretical requirements would suggest. Wilkinson, Billing, Nagy and Stewart (1949), in a study of patients after gastric operations, observed this sodium and chloride retention in the first week after operation in patients who otherwise might be considered as stabilized in regard to fluid and electrolyte requirements. In 1949 also, Blixenkrone–Møller showed that, following operation, an increased potassium excretion can be detected within the first six hours after operation. Wilkinson, Billing, Nagy and Stewart (1950) also demonstrated this phase of increased loss of potassium in the urine during the first three days of the post-operative phase. These observations have tended to show that this urinary potassium loss is different in degree from the urinary nitrogen loss, and tends to occur at an earlier phase in the post-operative period.

It has now become clear therefore that the incident of an operation is associated with an increased urinary potassium excretion, and a retention of sodium chloride and water by the body. Operation is used here in the widest sense not only to include the surgical trauma, but the anaesthetic, the pre-medication and the apprehension, all of which may be considered an integral part of an operation. It has become clear also that these changes occur after quite minor operations where no fluid or electrolyte imbalance might occur (MacPhee, 1953), or in more severe operations, where all losses are accurately replaced.

The cause of these metabolic changes remains a matter for debate. Wilkinson and his associates believed that they could be accounted for by the transudation of sodium chloride and water through the capillaries at the site of tissue damage, and by the leakage of potassium from damaged cells. That such changes do occur at the site of operation is certainly correct. These changes have also been shown to occur in association with increased adrenocortical activity as a result of operation (MacPhee, 1953). As similar changes can be produced by the administration of the adrenal cortical steroids, there is something to be said for this theory. Le Quesne and Lewis (1953) consider that the sodium chloride and water retention are indeed due to adrenocortical activity, but in addition, they consider there is an earlier phase of water retention resulting from increased secretion of the pituitary anti-diuretic hormone. Obviously a considerable amount of work remains to be done to clarify these problems, but certain direct conclusions can be drawn at this stage on the management of fluid and electrolyte problems in the early post-operative phase. These conclusions deserve wider recognition because failure to recognise them may lead to some of the catastrophes with which this stage is fraught.

In the first week after operation, it remains a primary consideration to replace such water and salts as are lost. We may expect, however, a considerable sodium chloride and water retention during this period to such an extent that the normal common salt requirements need

not be expected. Provided, indeed, all deficiencies and abnormal loss are corrected, there is no need to supply any further saline during this phase until sodium chloride can be detected again in the urine in appreciable amounts. Such measures will prevent the saline overloading and water-logging of the patient, mistakes which are still too frequently encountered. During the first three days at least there is also an increased urinary potassium loss, as much as the equivalent of three grams of potassium chloride being excreted daily. As this potassium is being mobilised from the cells, the extracellular (and therefore plasma) potassium concentration remains normal or is even elevated for some time. Care must therefore be taken if potassium is supplied in any quantity immediately after operation, as toxic extracellular concentrations can rapidly be reached. In this connection, it is interesting to remember that potassium leaks out of the erythrocytes of stored blood to such an extent that the serum of stored blood may itself be toxic.

POTASSIUM DEFICIENCY

The greatest loss of potassium in the urine takes place in the first three post-operative days, and normally needs no correction if the patient is able to take a normal diet by mouth before or at that time. When, however, a pre-existent potassium depletion is already present, or where oral feeding is not possible after the third post-operative day, potassium deficiency may well occur. Deficiency of potassium leading to symptoms has been reported by Brown, Currens and Marchand (1944) in chronic nephritis, by Govan and Darrow (1946) in diarrhoea, by Lubran and McAllen (1951) in idiopathic steatorrhoea, and by Hawkins, Hardy and Sampson (1951) in pyloric stenosis. A potassium deficiency may therefore be expected in all cases where vomiting or diarrhoea has been a feature of the disease before operation. Such deficiency, as we have seen, is enhanced by the operation itself, and may indeed be made more severe by the giving of large saline infusions, a factor which Gamble (1942) has shown also increases the potassium excretion rate. It is therefore in the case of operation on the intestinal tract which has been preceded by vomiting or diarrhoea or both, and in which early oral feeding is not possible, that severe potassium depletion is likely to occur.

The treatment of such a deficiency depends partly on suspecting it before muscular weakness, cyanosis, and cardiac enlargement occur, and by treating the patient at an early stage. As has been indicated earlier, the serum potassium concentration is not a good index of *cellular deficiency*, as the latter may be present when the serum concentration is not markedly reduced. Potassium depletion is best estimated by assessing the potassium loss in the urine and the vomitus or intestinal aspirate, but this is both a troublesome and time-consuming method. Electrocardiographic changes, if recognized, do offer early evidence of severe depletion, and where deficiency is already suspected, prolongation of the Q–T interval, depression or inversion of the T wave, and depression of the S–T segment are progressive signs that potassium replacement therapy is urgently required. Elkinton and Tarail (1950) recommend that, if parenteral replacement is envisaged, the maximum potas-

sium strength of the solution used should not exceed 80 milli-equivalents per litre, and no more than 20 milli-equivalents (i.e. 250 ml.) should be administered in an hour. It will be appreciated that even this strength of potassium is twenty times greater than the potassium concentration in the extracellular fluid. If, therefore, such a concentration of potassium is given, toxic concentrations of potassium may be built up in the extracellular space while cellular potassium depletion is still present. The solution obtained by dissolving 4.5 grams K_2HPO_4 and 1 gram of KH_2PO_4 in 1 litre of water contains about 60 milli-equivalents of potassium, and if given over a period of 4–6 hours is suitable in severe potassium depletion. Darrow (Darrow and Pratt, 1950), recommends his "K Lactate" solution, which corrects also the frequently associated acidosis. This solution contains 4.0 grams sodium chloride, 2.7 grams potassium chloride and 52 ml. of molar sodium lactate per litre. The potassium content is approximately 36 milli-equivalents per litre, and therefore, even in severe potassium depletion, a litre should not be given in less than 3 hours.

POTASSIUM INTOXICATION

Potassium intoxication is not normally encountered, except in renal failure, or when an overdose of a potassium salt is given. If such an overdose is suspected it is important to be able to treat the condition rapidly. The objects of treatment are to reduce the extracellular potassium concentration by increasing cellular potassium uptake, and by increasing the renal excretion. The latter is best obtained by promoting a simple water diuresis, but is a relatively slow process. Fenn (1939) showed that potassium is deposited in the liver along with glycogen, and it is now known that the extracellular potassium concentration falls during this process. A dramatic, though temporary, fall in the serum potassium can therefore be obtained by giving glucose and insulin by injection, and the response to treatment can be assessed by serial serum potassium determinations.

Clinical and experimental studies leave no doubt that fluid and electrolyte imbalance cannot now be treated by rule of thumb methods. Each patient represents a separate problem in therapy, a problem which can only be solved by adequate data and sufficient knowledge. There is no place for a random choice of inappropriate electrolyte and hit-or-miss methods. Each deficiency must be estimated and corrected as rapidly as is consistent with safety. This is the surest way of increasing the range of operability, and reducing the rate of mortality.

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THE TEACHING OF ANAESTHESIA TO MEDICAL STUDENTS

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THE purposes of this paper are (1) to define the problems involved in teaching anaesthesia to medical students and (2) to suggest possible ways out of the difficulties.

A questionnaire on teaching was sent to, and replies were received from 20 Medical Schools in Great Britain.

ANALYSIS OF QUESTIONS

Each question will be considered separately in what follows, and a general statement based on the answers will be made, and followed by relevant comments. For the purpose of this comparison each Medical School has been given a number.

Q. 1.

WHAT IS THE NUMBER OF ANAESTHETISTS WHO ARE AVAILABLE FOR TEACHING? (a) FULL-TIME. (b) PART-TIME. (See Table I.)

General Statement.

In the 20 centres there were 227 teachers, 65 being full-time and 162 part-time. Fifteen centres had between 6 and 12 teachers; the largest number at any one centre being 24 and the smallest 6.

Comment.

These numbers are no guide in deciding teaching requirements because they have arisen from the needs of anaesthetic services. They do show, however, the number of teachers available in some 20 centres and this will be reconsidered in relation to the total number of students.

Q. 2.

WHAT IS THE APPROXIMATE NUMBER OF STUDENTS QUALIFYING EACH YEAR? (See Table II.)

General Statement.

Twelve of the centres trained between 50 and 80 students per year, the largest number was from 250–300 and the smallest was 30. The total number of students attending 20 centres was approximately 1,815 per year.

TABLE I

Number of anaesthetists available for teaching

Centres	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
F.T.	4	6	—	4–5	5	4	1	—	2	5	3	7	2	1	4	10	—	2	—	5
P.T.	6	6	6	2–3	15	7	7	12	4	4	6	8	5	12	6	10	8	9	24	5
Totals	10	12	6	6–8	20	11	8	12	6	9	9	15	7	13	10	20	8	11	24	10

F.T. = Full-time (includes consultants, senior registrars, registrars, senior hospital medical officers).
P.T. = Part-time consultant.

TABLE II

Approximate number of students annually

Centres	1	2	3	4	5	6	7	8	9	10
Students	70–80	60	40–60	60	100	90–100	50	80	55	45
Centres	11	12	13	14	15	16	17	18	19	20
Students	30	180	80	60–70	80	200	100	56–60	250–300	80

Comment.

These results relate to the period preceding 1953, but the number of students will vary from year to year. There is approximately 1 teacher to 8 students.

Q. 3.

HOW MANY LECTURES ARE DEVOTED TO ANAESTHESIA. (See Table III.)

General Statement.

From 6 to 10 lectures were given in the majority (16) of the centres, the largest number of lectures in a course being 12, and the smallest number from 4 to 5.

Comment.

In a course of from 6 to 10 lectures a general outline only can be given.

Q. 4.

HOW MUCH OF THE CURRICULUM IS SET ASIDE FOR PRACTICAL ANAESTHETIC ADMINISTRATION? (See Table IV.)

General Statement.

In the largest group of centres (8), 4 weeks were set aside for practical anaesthesia instruction, this period being in some instances shared with other subjects. The longest time was 12 weeks.

Comment.

The practical aspects of modern anaesthesia cannot be covered in 4 weeks. A period of 2 weeks continuous instruction, however good the opportunities, would be considered barely sufficient for minor procedures in anaesthesia, but the lessons learnt from continuous instruction might be retained better than those from intermittent teaching.

Q. 5.

WHAT SORT OF ANAESTHETICS DO THE STUDENTS HAVE THE OPPORTUNITIES TO GIVE PERSONALLY UNDER SUPERVISION? (See Table V.)

TABLE III

Number of lectures devoted to anaesthesia

Centres	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Lectures	12	12	6	4–5	6	6	8	10	6–8	12*	6	8	10	6	10	10	6	6	6	6

* 6 are films.

TABLE IV

Period allowed for practical instruction in anaesthesia

Centre	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Period in weeks	4	12	4	12	4	4	4	2	6	4	2	3	G.S.	4	3	G.S.	?	12	4	?

G.S. = during period allocated for general surgery.

TABLE V

The anaesthetics which the teachers state are used for supervising students

	No. of centres in favour
Ethyl chloride	2
Ether	8
Nitrous oxide and oxygen	7
Nitrous oxide, oxygen and ether	11
Nitrous oxide, oxygen and trichlorethylene	6
Cyclopropane	1
*Thiopentone	11
Spinal	1
Relaxants	1
Pethidine	1

* Usually for induction.

General Statement.

There were only 5 anaesthetic groups which were specified 6 or more times. These were nitrous oxide, oxygen and ether; thiopentone; ether; nitrous oxide oxygen, and finally nitrous oxide, oxygen and trichlorethylene. Only 1 centre for each was in favour of allowing students to use (a) relaxants, (b) spinal anaesthesia and (c) pethidine. Only 2 centres were in favour of using ethyl chloride.

Comment.

From the answers given it would seem that the opportunities for using ethyl chloride are rare, and yet here no mention has been made of divinyl ether; it is presumed that teachers feel that ether, in the case of children, an thiopentone, for adults, are more suitable agents for students.

Q. 6.

ARE ANAESTHETIC DRESSERSHIPS ESTABLISHED?

General Statement.

The answers show that anaesthetic dresserships are established in 7 centres; 8 centres have none and the comment from 2 was that they did not understand the meaning of "anaesthetic dresserships." One centre seconds students from surgical firms for weekly periods. One has anaesthetic apprenticeships for 1 month on a voluntary basis. In another, practical work is done during the time of surgical dressing.

Comment.

No one has defined what is meant by an "anaesthetic dressership", but in general surgery a dressership means that, during the whole of the daytime, (apart from lectures), the student is able to confine his activities to surgery. In some instances time is allotted to anaesthesia during the period allocated for surgery, and when there are no opportunities for giving anaesthetics the student returns to consider surgical problems, but he must have sufficient time to pursue his studies in anaesthesia without interruption, even when there are temporarily no anaesthetics to administer. Tutorial instruction might well be given at such a time. "Anaesthetic clerk" might be a better term for the anaesthetic post, and the duration of the "clerkship" will depend upon the ground to be covered and the number of anaesthetics which can be given under supervision.

Q. 7.

WHAT OPERATIONS DO YOU CONSIDER MOST USEFUL IN CHOOSING CASES SUITABLE FOR STUDENT ADMINISTRATION? (See Table VI.)

TABLE VI

The operations considered the most useful in choosing cases suitable for student administration

Operation groups	Minor surgery	Relatively minor surgery	Obstetrical	Gynaecological	Orthopaedic	E.N.T.	Dental	Acute abdominal
	Includes Cas. OPs Circs.	V.V. Hernias Appendix, etc.						
No. of suggestions from centres	27	26	4	6	9	9	8	1

General Statement.

Minor operations and relatively minor operations, like herniorrhaphy and appendicectomy are considered the most useful in choosing cases suitable for student administration.

Comment.

Of the 2 groups of answers classified as (1) minor surgical operations in the Casualty Department, and (2) the relatively minor surgical operations, the former would seem to be the most useful, as in most hospitals these are performed daily, whereas the latter occur intermittently amongst the major operations in the general surgical lists. Thus it is easier to organize practical teaching for anaesthetics in the Casualty Department.

It is of interest that teachers are not generally in favour of students tackling the acute abdominal emergency, even if supervised. Ear, nose and throat, and dental operations are relatively unpopular choices. This may be because of the potential danger inherent in the fact that, in both these groups, the student is at some disadvantage in maintaining a clear airway. The reasons against allowing students to practise on women in labour are that (1) they are unprepared and liable to suffocate from vomiting and (2) there are two lives involved. On the other hand there are not enough trained anaesthetists available in the country to cope with such cases in domiciliary practice, and these are just the cases the ordinary practitioner is likely to meet.

Q. 8.

WHAT ANAESTHETIC AGENTS AND TECHNIQUES DO YOU CONSIDER SHOULD BE UTILIZED TO GIVE THE STUDENTS PERSONAL OPPORTUNITIES FOR PRACTICE UNDER SUPERVISION?

General Statement on Agents.

Eight different agents were specified in the answers; of these ether was suggested by 19 centres, nitrous oxide by 18, thiopentone by 14, trichlorethylene by 10, ethyl chloride by 6, divinyl ether by 2, chloroform by 2 and hexobarbitone by 1. Relaxants were suggested by 2 centres but these are not strictly anaesthetic agents.

Comment.

Ether remains the best agent for student practice with nitrous oxide as the next best.

General Statement on Techniques.

Apart from artificial respiration which was cited by 1 centre, 7 techniques were mentioned including partial rebreathing by 18, intravenous by 14, open by 12, nasal by 2, gas air analgesia by 2, local methods by 2 and closed circuit methods by 1 centre.

Comment.

The partial rebreathing technique is considered the best. Probably the reason why most teachers favour teaching the practical use of partial rebreathing methods, rather than open ether anaesthesia, is that they believe, as most institutions are now equipped with rebreathing apparatus, the student will use this in preference to the older methods. There is, however, less likelihood for the relatively untrained anaesthetist to get into trouble with the simpler methods. For example, with nitrous oxide and oxygen, not only may he give too little oxygen, but the total flow from his machine may be inadequate; he may use an apparatus in which the cylinders are connected up in the wrong way, though this is becoming less of a possibility than heretofore. By fastening the retaining straps too tightly he may obstruct the patient's airway, and by having the expiratory valve under tension he may cause the patient to breathe against pressure. For these reasons it seems that open ether anaesthesia should be considered preferable to partial rebreathing. If premedication is adequate but not overdone, and induction is aided by a safe and rapidly acting agent, for example, nitrous oxide or divinyl ether, the post-operative results following open ether anaesthesia are probably better than those of the former group. For the past six months the writer has been using open ether for practically all the patients presenting themselves on a general surgical list. The operations have included mainly herniorrhaphies, appendicectomies, gastroenterostomies, cholecystectomies, and radical breast operations. He finds that the post-operative results are not very different from those following so-called modern anaesthesia.

Eight different single anaesthetic agents have also been included (excluding cyclopropane*). It is surprising that local anaesthesia has only been mentioned by 2 centres. Local anaesthesia without the use of vasoconstrictor drugs would appear to lend itself admirably for student practice, particularly for operations upon the fingers.

General Statement on Combination of Agents.

Table VII shows the 12 combinations of agents which have been mentioned, nitrous oxide oxygen and ether being the most popular suggestion.

TABLE VII

Anaesthetic combinations for student practice

Combinations	Centres advising
Nitrous oxide, oxygen and ether	11
Nitrous oxide, oxygen and trichlorethylene	8
Thiopentone and nitrous oxide, oxygen ...	5
Nitrous oxide, oxygen	5
Thiopentone, nitrous oxide, oxygen and ether	4
Nitrous oxide, oxygen (nasal)	3
Ethyl chloride and ether	3
Thiopentone, nitrous oxide, oxygen and trichlorethylene	2
Nitrous oxide, oxygen, trichlorethylene and ether	1
Thiopentone, nitrous oxide, oxygen and relaxants	1
Chloroform and ether	1
Divinyl ether and ethyl ether mixture ...	1

* Recently Bourne (1952. *Lancet*, **2**, 705) has suggested the use of cyclopropane by students for casualty and dental operations.

Comment.

If a few well tried simple anaesthetic agents or simple combinations of agents only were taught under practical supervision, more time could be given to them than to a large number of agents and combinations.

Q. 9.

WHAT CLASS OF ANAESTHETIST DIRECTLY SUPERVISES THE STUDENTS' PERSONAL ADMINISTRATION?

General Statement.

In most centres the bulk of the teaching was done by part-time consultants.

Comment.

When a student is supervised, his mistakes have to be corrected and the patient's life may be in danger; therefore the burden of teaching practical anaesthesia should ideally rest on the most experienced shoulders.

Q. 10.

(a) DO THE CONSULTANT SURGEONS CONSENT TO REGULAR ANAESTHETIC INSTRUCTION BEING GIVEN TO UNDERGRADUATES DURING THEIR LISTS?

(b) IF NOT, WHAT CLASS OF SURGEON DOES ALLOW INSTRUCTION?

General Statement.

The answer to the first question was in the affirmative in the majority of instances, but several stressed the need for tact and discretion, and the need not to interfere with the operating schedule.

Comment.

The consultant surgeons generally undertake the most major surgical procedures and these are not the most suitable opportunities for student practice.

Q. 11.

WHEN THE STUDENTS ARE AVAILABLE TO GIVE ANAESTHETICS, DO YOU FIND THAT THE SURGICAL CASES ARE FREQUENTLY UNSUITABLE?

General Statement.

The answer was in the affirmative in the case of 16 out of the 20 centres.

Comment.

This answer reveals the reason why the opportunities for student practice are seriously curtailed. It would seem that here is more evidence for the need in the teaching hospital to have regular lists of relatively minor operations on reasonably fit subjects. These lists should be performed at regular times, and the students organized so that each group has his or her fair share in giving anaesthetics under supervision in suitable cases.

Q. 12.

(a) DO THE STUDENTS HAVE TO PRODUCE ANY RECORD OF HAVING ADMINISTERED ANAESTHETICS UNDER SUPERVISION?

(b) IF SO, HOW MANY ANAESTHETICS ARE THEY EXPECTED TO GIVE?

General Statement.

(a) Students have to produce records in 13 centres only.

Comment.

The assessment of the value of a course of practical instruction in anaesthesia depends upon the knowledge of what is performed by the student, and a record gives some indication of this.

General Statement.

(b) No number was specified by 9 centres and, in the others, numbers ranging from 6 to 30 were required.

Comment.

Students ought to take advantage of the largest possible numbers of opportunities, but it would be unreasonable to expect them to produce evidence of any specific number. Nevertheless, they should keep a record so that the teacher can decide whether further opportunities should be created for them.

Q. 13.

WHAT DO YOU CONSIDER ARE THE ESSENTIALS OF AN ANAESTHETIC COURSE?

General Statement.

Many of the teachers expressed their dissatisfaction with the state of anaesthetic teaching today. Most felt that a course of lectures should be followed by a period of practical work, but the opportunities for this had been considerably reduced in recent years. A good point made by 1 centre was that the head of the department interviewed the students after a period of practical work; if the ground covered was found to be unsatisfactory, further opportunities were presented.

Here is what Professor Macintosh of Oxford University wrote:

"One of the great difficulties appears to me to be that if they are to be taught so-called modern anaesthetics, then the time put aside for this is grossly inadequate. On the other hand, are we justified in teaching them the type of anaesthetics which we ourselves would not normally administer? If so I don't know any other specialty which follows this practice. For instance, a surgeon would not teach an undergraduate to take out an appendix in any way other than the one he would use himself. My own feeling is that the teaching of anaesthetics is becoming more and more a post-graduate affair."

Dr. John Gillies of the Royal Infirmary, Edinburgh, states:

"The medical curriculum is so overcrowded that it is impossible to do anything in regard to anaesthesia, except make a grand gesture which may at least have the advantage of demonstrating to the undergraduate that the methods he sees in hospital cannot be applied in general practice. I should prefer to teach the subject to post-graduates only, including those in training as general practitioners."

Another authority states:

". . . in these days of complicated surgery, to get sufficient simple material to give a good anaesthetic teaching course is almost impossible" and "I cannot help thinking that the day must come when the teaching hospital will have to be divided, both for in- and out-patients, into two halves, one devoted to student teaching, and the other to the consultant . . ."

Dr. Featherstone stressed the importance of a thorough training even if only minor anaesthetics are to be given.

He writes:

". . . an anaesthetic, however brief, for the simplest of operations, may lead in unskilled hands to sudden and unjustifiable death. If an individual is to bear the responsibility of giving an anaesthetic at all, then he must have received full practical training and experience in the particular method which he employs."

Dr. Brennnan states:

"The one condition for which the practitioner should be competent to anaesthetize is a forceps delivery, in a private house, and this is one condition on which, in most medical schools, he has never received any practical instruction."

Q. 14.

DO YOU CONSIDER THAT THE AVERAGE MEDICALLY QUALIFIED PRACTITIONER IS COMPETENT TO UNDERTAKE THE ANAESTHETIC WORK HE MAY BE CALLED UPON TO DO (a) AS A HOUSE SURGEON (b) AS A GENERAL PRACTITIONER?

General Statement.

(*a*) Only 3 centres held that the house surgeon was competent and 13 disagreed. Much depended on the practical opportunities and on the individual ability to learn; some argued that supervision ought to be continued and others felt that the work should be limited to minor procedures in anaesthesia.

(*b*) Only 5 centres agreed that the general practitioner was competent to give anaesthetics and 12 did not. Several advocated a period of further training.

Comment.

Since teachers feel that, under existing conditions, the newly qualified practitioner, either as a house surgeon or as a general practitioner, is not competent to do anaesthetic work, unless a further period of training has been given, it is clear that most of the present teaching systems are inadequate.

DISCUSSION ON THE FACTORS WHICH HAVE CAUSED THE DIFFICULTIES IN TEACHING

How have these difficulties arisen? A little over 10 years ago, medical students had many opportunities of learning the art of open ether anaesthesia, and also managed to become fairly expert with nitrous oxide using simple apparatus comprising, for example, cylinders, a foot key, a rubber bag surmounted by a three-way tap, and a mask. In many hospitals the anaesthetic staff were almost non-existent, and students were encouraged to give anaesthetics under the supervision of either the surgeon or a member of his team. By the time the student qualified he had become reasonably proficient and was at once allowed to work without supervision. If he embarked on nitrous oxide, oxygen, ether mixtures, the general standard of his work was not high, but he managed open ether fairly well.

Largely as the result of the stimulus of war, more specialists arrived on the scene to take advantage of new anaesthetic posts in the National Health Service, and about this time the subject was undergoing revolutionary changes leading to methods which have made anaesthesia more palatable to the patient, and which have created easier conditions for the surgeon. As the scope of the subject enlarged, so did the potential dangers in relatively untrained hands. As a result the student is now no longer encouraged to give anaesthetics when he undertakes his surgical dressing, for there is usually a qualified anaesthetic staff with post-graduates in training. Surgeons are loath to return to the old conditions, and naturally they demand what they think is best. When the student qualifies, his practical experience in this subject is probably mainly limited to simple procedures in the Caspalty Department. If, on qualification, he is ever called upon to administer anaesthesia for more advanced work he may wisely refuse to do so, because he lacks sufficient practical training. Doubtless he will have read of the declaration of Mr. Justice Oliver, that a

recently qualified house surgeon should not be allowed to use a barbiturate for the purposes of anaesthesia, notwithstanding the fact that another section of the law, namely the General Medical Council, had, through its examiners, certified that the house surgeon was qualified to administer anaesthesia.

CONSTRUCTIVE SUGGESTIONS FOR INCREASING THE OPPORTUNITIES FOR STUDENT PRACTICE

If greater efforts are to be made to increase the efficiency of practical training, medical students will have to be apprenticed to teachers working as anaesthetists in the casualty and out-patient departments. Since these departments do not provide sufficient range of material, they do not, for example, include operations such as herniorrhaphies, appendicectomies or for the resection of varicose veins, and since these are common operations and are generally agreed to be essential teaching material, special additional lists would have to be in existence. (At present such operations are performed by the surgical trainees, after the list of major operations has been completed by the consultant. This type of procedure is of more value to the surgical student to watch than the major operations generally attended; this being an additional reason for the need for special lists.) Special tutorials on anaesthesia in and out of the wards would also be essential to consolidate the knowledge gained from practical work.

Organization of Practical Work.

The period allotted for practical instruction will depend on the extent of the material opportunities and the total number of students. Suppose there are 60 students and a daily casualty list, 2 out-patient operation lists and 2 lists of relatively minor operations (herniorrhaphies). Suppose on an average there are 6 operations per day in casualty, 6 on out-patients and 6 on the extra list. This means that per week there will be:

	Operations per week	
	36	Casualty
	12	Out-patients
	12	Simple operations
Total	60	

If the students are taken in groups of 6 they will get approximately 10 operations per week each. In 1 month they would have done 40 anaesthetics. The whole of the 60 students could then be organised to get 40 anaesthetics in 10 months.

What to Teach.

If the agents and methods taught were few and simple more would be retained by the student.

He could be taught how to give open ether to infants (circumcision operations), nitrous oxide oxygen with possibly cyclopropane and oxygen for adults for casualty work, open ether or nitrous oxide oxygen ether for operations in the special lists, herniorrhaphy, appendicectomy and the like, and for out-patient operations.

The Teaching Staff.

Part-time or full-time consultant anaesthetists at teaching hospitals are often under contract with regional boards, and are usually employed up to the maximum number of sessions both in and outside the

hospital. They anaesthetize for consultant surgeons. Although consultant anaesthetists at a teaching hospital are responsible for teaching, their work is necessarily designed so that they anaesthetize the most difficult cases, but these are the most unsuitable for teaching. The alternative is to have a number of special appointments with a set number of teaching sessions. Teaching hospitals making new appointments might well consider this aspect and allow for some provision to cover lists suitable for student instruction.

Suppose, as in the example cited above, there are 6 consultants and 1 senior registrar. Suppose the consultants are employed up to maximum sessions. (There will be no private work in teaching sessions so that some additional remuneration ought to be forthcoming to allow for this.) There are 10 sessions per week (6 sessions in casualty, 2 in out-patients and 2 for simple operations). The senior registrar could undertake 2 sessions per week, and each of the consultants would do 1 session to make up the remaining 6. It would seem reasonable for each consultant at a teaching hospital to undertake at least 1 session per week which is specially designed for teaching.

FURTHER POSSIBILITIES

An alternative approach is that undergraduate anaesthesia could be treated as a general outline with a little practical instruction, and the student warned of his limitations and that he is a public danger as an anaesthetist. The teaching activities of the part-time consultants could then be confined mainly to post-graduates.

A third possibility is to teach students modern anaesthesia from the start. Even if more time were allowed, it is doubtful whether there would be enough in which to make the student safe. It takes about a year before a whole-time post-graduate trainee anaesthetist is reasonably safe with modern anaesthesia; and he is not capable in the special branches of the subject. Thus when considering a batch of 60 students it is clear that training in modern anaesthesia could not be properly covered during the undergraduate stage.

It follows that if the opportunities for practical teaching were increased and a newly qualified man could safely undertake to give anaesthetics for simple operations in relatively normal subjects, and if he had further practice under supervision in between qualification and registration, then the activities of the skilled anaesthetist could be conserved; in view of the declining numbers of men taking up the specialty such economy is now a necessity in some quarters. On the other hand the increased practical opportunities may still not be enough. We must decide either to concentrate more on the undergraduate, or to regard him as unfit to administer anaesthetics unsupervised. In this latter case the General Medical Council might well consider modification of the existing pronouncements with regard to this specialty.

FACILITIES FOR POSTGRADUATE STUDY IN ANAESTHESIA

THE *British Journal of Anaesthesia* has endeavoured to ascertain what facilities are available in the United Kingdom for the training of postgraduates in anaesthesia. Inquiries have been made at each University and Medical Teaching School as to opportunities offered for such instruction.

From the answers received it is clear that, at the great majority of the centres, routine practical instruction is given only to the trainees who hold appointments in the hospitals concerned, but at every teaching centre visitors, particularly from overseas, are welcomed and encouraged. Generally speaking, such visitors can receive practical clinical training in anaesthesia by registering as postgraduate students or clinical assistants, joining a Medical Protection Society, and being admitted to the Medical Register if from overseas. In practically every instance meetings of the anaesthetic trainees are held at varying intervals for tutorial instruction and discussion.

The following centres provide special facilities and courses of instruction for postgraduates.

FACULTY OF ANAESTHETISTS, ROYAL COLLEGE OF SURGEONS OF ENGLAND.

A. *Anaesthetic Course for Overseas Students.* A two-year course is provided for overseas students at a fee of £100 per annum, exclusive of board and lodging. Students commence this course in October or April of each year, and take a course of three months' whole-time lectures in the basic sciences (these lectures are the same as those attended by students studying for the Primary Fellowship of the Royal College of Surgeons of England). On completion of this course of lectures the student is sent to a clinical training centre to study and gain experience in the practice of anaesthesia. It is usual for the students to be attached first to the general hospitals, and to complete their work at the more specialized centres in which there are Plastic Surgical or Thoracic Units. During the two years the students are also able to attend the other courses in anaesthesia and pharmacology which are provided by the Faculty, and are granted study leave from their hospitals for this purpose.

B. *Short Course of Anaesthetic Lectures.* This course, of three weeks' duration, is designed to help those students who are studying for examinations in anaesthetics. It consists of forty lectures, each of one hour's duration, together with clinical instruction in medicine and anaesthesia for those who wish it. The lectures take place at the Royal College of Surgeons and the clinical work is arranged at various hospitals in the London area. The fee for the full course is £18 18*s*., for the lectures only £15 15*s*. Single lectures may be attended at a cost of 10*s*. each, and an extra fee of £15 15*s*. is charged for the special tutorials, which are held each evening during the three weeks.

C. *Course of Pharmacology Lectures.* This course is designed for those who wish to study for the Primary Fellowship of the Faculty of Anaesthetists of the Royal College of Surgeons examination, and has been so arranged that it can be taken generally with the three-month course of lectures in the other basic sciences, or during the course of lectures in Anaesthetics described above, when those taking these lectures must miss the clinical instruction in hospitals. Sixteen lectures are given, for which the fee is £6 6*s*. Single lectures may be attended at a fee of 10*s*. each.

THE UNIVERSITY OF BRISTOL.

Courses of lectures are given from time to time, and individual and group tutorials are regularly arranged.

THE UNIVERSITY OF DURHAM.

Lectures are available in the basic sciences for all postgraduates (anaesthetists and otherwise), and regular small group tuition is arranged by the Department of Anaesthetics for junior staff, in clinical subjects as well as anatomy, physiology and pharmacology.

THE UNIVERSITY OF GLASGOW.

A basic science course (anatomy, physiology, biochemistry, pathology and bacteriology) of eight weeks' duration is organized by the University. Primarily designed for F.R.C.S. candidates, it is available for anaesthetists, but the course of instruction does not include pharmacology.

THE UNIVERSITY OF LIVERPOOL.

A full-time course of postgraduate instruction in anaesthesia, limited to twelve students, begins on October 1, and lasts for one year. The course combines instruction in the practical administration of anaesthetics with lectures and demonstrations in anatomy, physiology, pathology, physics, pharmacology, medicine and surgery, and anaesthesia. For the purpose of gaining practical experience, the students are found suitable appointments in recognized general hospitals within the Liverpool area. The fee for the course is £60.

THE UNIVERSITY OF LONDON: POSTGRADUATE MEDICAL SCHOOL OF LONDON.

In view of the increasing demand for teaching in anaesthetics, a university department in this subject is in process of formation.

Anaesthetic courses are carried on throughout the year for postgraduate students. For the most part, students attend for a period of six months, which they utilize as part of their specialist training and incidentally in studying for the specialist qualifications; the remainder being graduates who wish to take a refresher course in anaesthetics lasting from two to four weeks.

In each case great stress is laid on the practice of anaesthetics and, wherever possible, all students are encouraged to administer anaesthetics of every type under the supervision of the staff. In addition demonstrations are carried out, and recently a short course of lectures has been instituted.

THE NEW EXAMINATIONS

DIPLOMA OF FELLOW OF THE FACULTY OF ANAESTHETISTS

REGULATIONS

1. The diploma of Fellow of the Faculty of Anaesthetists of the Royal College of Surgeons of England may be granted (*a*) to those who possess a qualification registrable in the British Medical Register, and (*b*) to graduates of Universities and Medical Colleges overseas, whose degrees are not registrable in the British Medical Register, under such conditions as may be determined by the Board of Faculty in each individual case.

Applications in such special cases must be addressed to the Examinations Secretary (see paragraph 6) and must be accompanied by certificates showing the date of obtaining a medical and surgical degree and particulars of relevant post-graduate experience.

2. Candidates for the Diploma are required to pass two examinations, namely, the Primary Examination and the Final Examination. Exemption from the Primary Examination will, however, be allowed to those who produce evidence that they have passed the Primary Fellowship Examination of the Royal College of Surgeons of England, or of the Royal Australasian College of Surgeons, or (after June 1, 1951) of the Royal College of Surgeons in Ireland, or of the Royal Faculty of Physicians and Surgeons of Glasgow, or of the Royal College of Surgeons of Edinburgh; or to those who have passed Part I of the Examination for the D.A. (R.C.P. Lond. & R.C.S. Eng.).

3. The fees payable for admission to the Primary and Final Examinations are set out in paragraphs 18 and 22.

4. The fees payable before the diploma can be granted, in addition to the fees payable for admission to the examinations are: In the case of Members of the Faculty eighteen guineas and in the case of all other candidates twenty guineas. These fees are not payable until both examinations have been passed.

5. The diploma of Fellow of the Faculty will not be granted to a candidate who has not attained twenty-five years of age. A candidate may, however, enter for the Final Examination before he has reached this age.

6. All enquiries and communications with reference to the examinations for the diploma must be addressed to the Examinations Secretary, Examination Hall, Queen Square, London, W.C.1.

7. Applications for admission to either examination must reach the Examinations Secretary at least twenty-one days before the examination begins.

8. The dates of the examinations are published annually in the examination calendar, obtainable free of charge from the Examinations Secretary.

9. Applications for admission to either examination must be accompanied by the required certificates and the full amount of the fee payable for the examination.

10. A candidate withdrawing an application for admission to an examination in

writing, may receive back the full amount of the fee paid, provided that such withdrawal is received before the date on which the applications are due, as shown in the examination calendar.

A candidate withdrawing an application for admission to an examination on or after the date on which applications are due—as shown in the calendar—or who fails to appear for an examination for which his entry has been accepted, may receive back one-half of the full amount of the fee paid.

The proportion of the fee to be returned may be varied at the discretion of the Board of Faculty on the production, within seven days of the withdrawal or failure to appear at the examination, of medical or other evidence of compassionate grounds satisfactory to the Board.

(Applications for the exercise of the Board's discretion under the foregoing paragraph must in all cases be addressed to the Examinations Secretary.)

11. A candidate who may desire to make representations with regard to the conduct of his examination must address them to the Examinations Secretary, and not in any circumstances to an Examiner.

12. The Board may refuse to admit to examination, or to proceed with the examination of, any candidate who infringes any of the regulations, or who is considered by the Examiners to be guilty of behaviour prejudicial to the proper management and conduct of the examination.

13. The Faculty does not make recommendations regarding text-books for the examinations.

14. Papers set at the several examinations will be published annually and obtainable only from the printers, Messrs. Taylor & Francis, Ltd., Red Lion Court, Fleet Street, London, E.C.4, at the price of 2*s*. (post free in the United Kingdom) for each year's papers.

PRIMARY EXAMINATION

15. The examination is held in the months of July and November, unless otherwise ordered.

16. The subjects of the examination are Anatomy, Physiology, Pathology and Pharmacology with special stress upon those general principles with which anaesthesia and analgesia are particularly concerned.

17. The examination is written and oral.

18. The fee payable for admission or re-admission to the examination is ten guineas.

FINAL EXAMINATION

19. The examination is held in the months of May and December, unless otherwise ordered.

20. The subjects of the examination are (*a*) Anaesthesia and Analgesia including pre-operative and post-operative care, (*b*) Medicine and Surgery, (*c*) the application of the basic sciences including Chemistry and Physics, to the specialty of Anaesthetics.

The examination will be written, oral and clinical.

21. Candidates who have passed the Primary Examination for the Fellowship of the Faculty of Anaesthetists of the Royal College of Surgeons of England, or who have been exempted therefrom (see paragraph 2), and have had clinical experience extending over not less than

three years subsequent to the date of having obtained a qualification specified in paragraph 1, may enter for the Final Examination on producing evidence of:

(*a*) Having held clinical house appointments, other than in Anaesthetics, for at least twelve months in a recognized hospital.

(*b*) Having completed not less than eighteen months whole-time appointments in Anaesthetics in a recognized hospital.

22. The fee payable for admission or re-admission to the examination is £21.

The following remarks are made in amplification of the above regulations:

Primary Examination.—There are two papers, each of three hours; Paper 1, Anatomy and Pathology; Paper 2, Physiology and Pharmacology. In each paper four questions have to be answered: there is a choice of two out of three in each subject.

Oral examinations, each of ten minutes, are held in each of the above four subjects.

It is understood that in future in the examination in Anatomy the candidate may be asked to identify elementary histological slides.

Final Examination.—This consists of two papers, each of three hours; Paper 1, four questions in Anaesthesia, three to be answered; Paper 2, three questions in Medicine and Surgery, two to be answered, and five questions in the Basic Sciences as applied to Anaesthesia, two to be answered.

In the clinical examination the candidate will be asked to examine and assess a patient for anaesthesia. He will be given twenty-five minutes with the patient and then will be examined on that, and perhaps other short cases, for thirty minutes. There are two oral examinations in Anaesthesia and the Basic Sciences as applied to Anaesthesia, each of thirty minutes.

DIPLOMA IN ANAESTHETICS (R.C.P. & S. Eng.)

REGULATIONS

1. The examination is held in the months of May and November in each year.

2. The examination comprises:

(*a*) Human anatomy and physiology, considered in relation to Anaesthesia.

(*b*) The history, theory, and practice of Anaesthesia, including: inhalation Anaesthesia; intravenous, rectal, and other methods of inducing Anaesthesia; local, regional, and spinal Anaesthesia in all varieties; Anaesthesia in its relationship to disease.

(*c*) Pre-operative investigation, preparation and medication; the recognition of post-operative complications and their treatment in so far as they are related to Anaesthesia.

(*d*) The pharmacology and elementary chemistry of drugs used for, or in association with, Anaesthesia.

3. The examination is both written and oral.

4. Candidates holding a qualification in Medicine, Surgery and Midwifery registrable in the British Register, or the M.D., or M.B., B.S. Degrees of any University recognized by the Examining Board in England, are eligible for admission to the Examination on fulfilling the conditions of these Regulations.

5. Candidates may enter for the examination, on producing evidence:

(*a*) Of having passed a recognized qualifying examination in Medicine, Surgery and Midwifery not less than twenty-four months prior to the date of the examination.

(*b*) Of having held the post of resident House Physician or House Surgeon in the general medical or surgical wards of a recognized general hospital for not less than six months.

(*c*) Of having held the post of resident or whole-time Anaesthetist in a recognized general hospital for not less than six months.

6. The above conditions of study may be modified at the discretion of the Committee of Management in the case of candidates (*a*) who have carried out original investigations in any branch of the science or practice of Anaesthesia, or (*b*) whose studies and practice have extended over a long period without fulfilling the exact conditions; but exemption will not be granted from any part of the examination.

7. Candidates must give 21 days' notice in writing to the Secretary at the Examination Hall, 8–11 Queen Square, London, W.C.1, of their intention to present themselves for examination, forwarding at the same time the necessary certificates. (Copies of the schedule of the required certificates must be obtained from the Secretary at the above address.)

8. (*a*) Applications for admission to the examination must be accompanied by the full amount of the fee payable. The fee for admission or re-admission to the Examination is £10 10*s*. 0*d*. Candidates who pass the examination are required to pay a further diploma fee of five guineas (£5 5*s*. 0*d*.) before the diploma can be granted, *see* paragraph 11. Cheques should be made payable to "The Examining Board in England" and crossed " Barclays Bank Ltd.".

(*b*) Candidates who withdraw their applications for admission to the examination, in writing, may receive back the full amount of the fee paid, provided that such withdrawal is received *before* the date on which the applications are due, as shown in the calendar of the Board.

(*c*) Candidates who withdraw their applications for admission to the examination *on or after* the date on which applications are due, as shown in the calendar of the Board —or who fail to appear for an examination for which their entry has been accepted—may receive back one-half of the full amount of the fee paid.

(*d*) The proportion of the fee to be returned may be varied at the dis-

cretion of the Committee of Management on the production, *within seven days* of the withdrawal or failure to appear at the examination, of medical or other evidence of compassionate grounds satisfactory to the Committee.

9. Any representation which candidates may desire to make with regard to the conduct of the examination must be addressed to the Secretary and not, under any circumstances, to any of the examiners.

10. The Committee of Management may refuse to admit to examination, or to proceed with the examination of, any candidate who infringes a regulation of the Examining Board in England, or is considered by the Committee to be guilty of behaviour prejudicial to the proper management and conduct of the examination.

11. Candidates who pass the examination and who pay the diploma fee of five guineas (£5 5*s*. 0*d*.) may be granted the "Diploma in Anaesthetics of the Royal College of Physicians of London and the Royal College of Surgeons of England".

There is one paper of three hours' duration, with five questions, all of which must be answered. The Oral Examination is for twenty minutes, of which ten minutes is spent with an Anaesthetist, and ten minutes with either a Physician or Surgeon.

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